Incidence and prevalence of hamstring injuries in field-based team sports: a systematic review and meta-analysis of 5952 injuries from over 7 million exposure hours

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ABSTRACT

Objective This study aimed to systematically review and meta-analyse the incidence and prevalence of hamstring injuries in field-based team sports. A secondary aim was to determine the impact of other potential effect moderators (match vs training; sport; playing surface; cohort age, mass and stature; and year when data was collected) on the incidence of hamstring injury in field-based team sports.

Design Systematic review and meta-analysis.

Data sources CINAHL, Cochrane Library, MEDLINE Complete (EBSCO), Embase, Web of Science and SPORTDiscus databases were searched from database inception to 5 August 2020.

Eligibility criteria Prospective cohort studies that assessed the incidence of hamstring injuries in field-based team sports.

Method Following database search, article retrieval and title and abstract screening, articles were assessed for eligibility against predefined criteria then assessed for methodological quality using the Critical Appraisal Tool for prevalence studies. Meta-analysis was used to pool data across studies, with meta-regression used where possible.

Results Sixty-three articles were included in the meta-analysis, encompassing 5952 injuries and 7 262 168 hours of exposure across six field-based team sports (soccer, rugby union, field hockey, Gaelic football, hurling and Australian football). Hamstring injury incidence was 0.81 per 1000 hours, representing 10% of all injuries. Prevalence for a 9-month period was 13%, increasing 1.13-fold for every additional month of observation (p=0.004). Hamstring injury incidence increased 6.4% for every 1 year of increased average cohort age, was 9.4-fold higher in match compared with training scenarios (p=0.003) and was 1.5-fold higher on grass compared with artificial turf surfaces (p<0.001). Hamstring injury incidence was not significantly moderated by average cohort mass (p=0.542) or stature (p=0.593), was not significantly different between sports (p=0.150) and has not significantly changed over the last 30 years (p=0.269).

Conclusion Hamstring injury represents 10% of all injuries in field-based team sports, with 13% of the athletes experiencing a hamstring injury over a 9-month period most commonly during matches. More work is needed to reduce the incidence of hamstring injury in field-based team sports.

WHAT ARE THE FINDINGS?

⇒ The incidence of hamstring injury in field-based team sports is 0.81 per 1000 exposure hours, while the prevalence is 13% for a 9-month period, increasing 1.13-fold for every subsequent month of observation.
⇒ Hamstring injury incidence has not changed over the last 30 years.
⇒ The incidence of hamstring injuries is moderated by non-modifiable and modifiable factors, with matches, increasing athlete age and grass surfaces (compared with artificial turf) associated with a greater incidence of hamstring injury.

HOW MIGHT IT IMPACT ON CLINICAL PRACTICE IN THE FUTURE?

⇒ Clinicians can expect a higher incidence of hamstring injuries in older athletes compared to younger athletes.
⇒ Clinicians can expect a higher incidence of hamstring injuries during matches compared to training.
⇒ Clinicians should consider the potential for higher incidence of hamstring injuries on grass surfaces compared to artificial turf during soccer.

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INTRODUCTION

Participation in sport leads to a host of physical[1] and psychological[2 3] health benefits. Beyond the many benefits of sporting participation, a primary concern is the occurrence of injury, which can range from minor (eg, muscle soreness)[4] through to the catastrophic (eg, death).[5] To maximise the benefits of sporting participation, minimising the risk of injury is of utmost importance.[6] Of the numerous injury prevention models presented in the sports injury literature,[6 7] all concur that understanding the epidemiology (ie, incidence and prevalence) of injury is a critical first step.

Across many field-based team sports (eg, soccer, rugby, Australian football, American football, Gaelic football, field hockey) hamstring injury is a continual burden that impacts the subsequent performance of the individual (both subjectively[8] and objectively[9]) and team.[10] Furthermore, in the professional sporting context the occurrence of hamstring injuries carries financial implications with the cost of a single injury proposed to be as high as €500 000.[11]

While the epidemiology of the hamstring injuries in field-based team sports is well studied[12 13] the synthesis of these data across multiple sports has yet to be reported. Such an analysis would provide a global understanding of the incidence and prevalence of hamstring injuries across various field-based team sports, as well as indicating which sports have higher incidence of hamstring injuries compared with others. This analysis would also inform the urgency for the initiation and implementation of improved prophylactic practices for specific sports, different exposure situations and athlete characteristics.

There is also benefit in understanding factors that may moderate the incidence or prevalence of hamstring injury. Factors such as exposure type (eg, match vs training, playing surface), participant characteristics (age, mass and stature) and sport played have been associated with or proposed to be associated with hamstring injury risk.[14] Exploring the effect of these factors on hamstring injury incidence or prevalence would provide a more detailed understanding of the epidemiology. Furthermore, multiyear data from European soccer indicates that the incidence of hamstring injuries is increasing.[12] Should this rising incidence of hamstring injuries across time be found across all sports, the urgency for preventative initiatives would be even stronger.

Therefore, the primary aim of this systematic review and meta-analysis was to determine the incidence and prevalence of hamstring injury in field-based team sports. A secondary aim was to determine the impact of other potential effect moderators (match vs training; sport; playing surface; cohort age, mass and stature; year when data was collected) on the incidence of hamstring injury in field-based team sports.

METHODS

Registration

This review was submitted for registration with the International Prospective Register of Systematic Reviews (PROSPERO) on 5 August 2020. The registration was updated on PROSPERO on 26 March 2021.

Literature search strategy

The literature search and study selection process were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. A comprehensive search of CINAHL, Cochrane Library, MEDLINE Complete (EBSCO), Embase, Web of Science and SPORTDiscus databases was conducted from database inception to 5 August 2020. The search strategy, including key terms and controlled vocabulary (ie, Medical Subject Headings terms) can be found in online supplemental table S1. The search terms were determined to align with the aims of the review. Following retrieval all citations were imported into EndNote V.X9 (Clarivate Analytics, Philadelphia, Pennsylvania, USA) where duplicate removal was performed.

Study selection

The title and abstract of retrieved articles were screened for inclusion by two authors (DSC and JTH) using Rayyan.[15] Following the title and abstract screening, a full-text review was completed to determine eligibility by three authors (DSC, JTH and AJSJ) and any disagreements were then discussed and resolved via consensus between these three authors and a fourth (NM) if necessary. Included in the current review were prospective cohort studies that reported the incidence of hamstring injuries with corresponding total (training and match) exposure hours for athletes competing in field-based team sports. During this process, it was identified that a high proportion of papers used the terms 'hamstring strain injury' or 'posterior thigh injury' instead of 'hamstring injury', which was not anticipated by the research team or considered as part of the registration of the protocol. A consensus was reached by the research team to include papers using all three terms in our main analysis. It was further agreed that an additional subgroup analysis be conducted for studies using the term 'hamstring strain injury', owing to its more specific injury classification. The population investigated was those participating in field-based team sports of any level. Only peer-reviewed publications in English were considered. Hand-searching of the reference list was performed by two authors (RGT and DO) on all included studies to identify any other potential articles for inclusion, with two authors (RGT and DSC) completing full-text review of these articles to determine eligibility.

Assessment of methodological quality

The Critical Appraisal Tool for prevalence studies from the Joanna Briggs Institute was used to provide an indication of methodological quality of each study.[16] Two authors (DSC and RGT) applied the Critical Appraisal Tool to each individual study, with any discrepancy between scoring discussed between these authors to reach a consensus. If a consensus could not be reached in this manner a third author (JTH) was used to resolve the dispute.

All studies were rated on nine criteria (online supplemental table S2). An individual study was considered to have low methodological quality if it had an assessment outcome of $<60\%$. Whereas studies with an assessment outcome of $\geq 60\%$ were considered to be of a high methodological quality.[16]

Data extraction

Extracted data pertaining to the key outcome measures included the total number of hamstring injuries, total exposure hours, number of participants at risk and total number of injuries (of any type) if available. In some cases, required data were not directly reported in the relevant articles, but were calculable from other data reported within the article. Data pertaining to participant characteristics, including age, height, mass, sex, sport and level of competition were extracted, as were methodological details including the definition used to determine the occurrence of an injury, the method of diagnosis of injury type, the number and year of seasons of observation, length of the season(s) and details of exposure scenario (eg, training vs match). Data extraction was performed by one author (NM) and checked for any discrepencies with the original article by one of three authors (JTH, RGT and DO).

Data analysis

Meta-analysis and meta-regression were conducted using the 'metafor' package[17] in R (R Core Team, 2021). Primary outcomes of this study included (1) the incidence of hamstring injuries per 1000 hours of exposure and (2) the prevalence of hamstring injuries (ie, the number of injuries as a percentage of the total population at risk). Following data extraction an additional primary outcome was added that was not preplanned which was (3) the proportion of which all injuries are composed of hamstring injuries. For each meta-analysis conducted, data were pooled across studies using a random effects model, with a restricted maximum likelihood method used to estimate variance. Note that we used a multilevel model to account for dependency when multiple cohorts were obtained from the same study (eg, different seasons, different regions). As prevalence was expected to be sensitive to the analysis period used by each study, we also included the prevalence period (in months) as a moderator for this model. Where additional data were available, we performed moderator (meta-regression) analysis to assess the impact of other potential effect modifiers on incidence rates. These moderator analyses were not preplanned, however, following data extraction the research team reached on consensus that there was sufficient data available to conduct these analyses and that the findings would be relevant and complimentary to the primary aim of the review. Specifically, we determined if the incidence rates were moderated by sport played, season (ie, the year in which data was collected), training versus match exposure, or playing surface type, as well as the average age, mass and stature of each cohort. Since mass and stature are related to age in younger cohorts, age was included as a covariate in these models. The outcome variables for each study (incidence rate, prevalence, hamstring injury as a proportion of all injuries) were first log-transformed prior to pooling, owing to the more favourable distribution properties of log-transformed data for meta-analysis, but we report that back-transformed estimate and 95% CIs for ease of interpretation. Additionally, we report the proportion of total variability due to between-study heterogeneity using the I^2 statistic,[18] as well as the number of cohorts (k), injuries and exposure hours included in each meta-analytical model. Each analysis was conducted for the maximum available number of studies; however we performed a sensitivity analysis to determine if our conclusions were robust to the exclusion of low methodological quality studies.

RESULTS

Search strategy

The search results are presented in figure 1. The initial search yielded 23 828 items from all databases. After duplicate removal and title and abstract screening, 734 articles underwent independent application of the selection criteria, resulting in 63 articles in the quantitative meta-analysis. The most common reasons for exclusion for otherwise eligible studies were not reporting total exposure hours[19–21] or not reporting hamstring injury-specific numbers[22 23].

Assessment of methodological quality

Across all included studies there was an average rating of 6 out of 9 (online supplemental table S3). Over two-thirds of the studies (68%, n=43) were determined to be high quality. The remaining studies (32%, n=20) were deemed to be low quality. Full details of the quality assessment for all included studies are provided in online supplemental table S3.

Description of studies

Participants

Across the 63 included studies,[12 13 24–84] a total of 7 262 168 exposure hours to field-based team sports from over 19 countries were included in the meta-analysis. Most of these exposure hours covered soccer (exposure=6 398 511 hours), followed by rugby union (exposure=742 028 hours), Gaelic football (exposure=67 797 hours), field hockey (exposure=25 857 hours), Australian football (exposure=15 478 hours) and hurling (exposure=12 497 hours). Most exposure hours came from elite or professional players (exposure=6 555 990 hours), while the remainder were amateur (exposure=357 748 hours), youth (exposure=141 442 hours), mixed (exposure=109 083 hours), semi-professional (exposure=38 361 hours) or unclear (exposure=59 544 hours). Not all studies reported participant characteristics, but of those that did, the average age, mass and height of

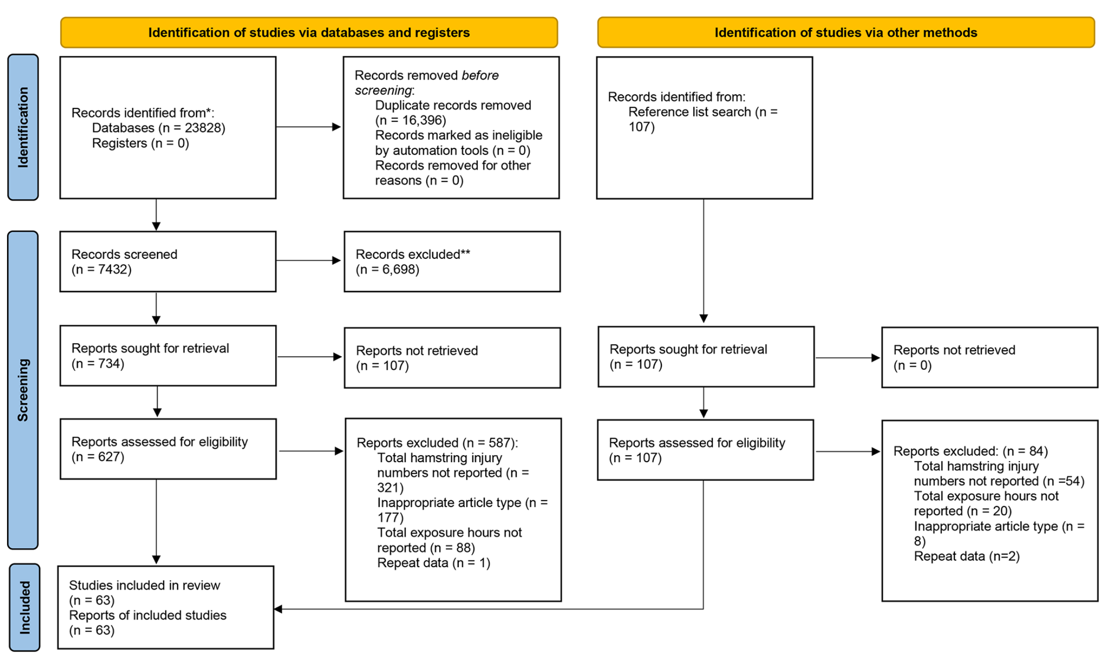

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow chart.[97] Note that 'Inappropriate article type' were articles that were not peer-reviewed original research articles suitable for inclusion, such as reviews, theses, editorials, abstracts and other articles not in English. 'Repeat data' were articles that contained the same information as other articles that were already included. In these circumstances, the articles with more intricately reported data were retained.

the included participants ranged from 6 to 44 years, 61 to 104 kg and 1.67 to 1.86 m, respectively. The vast majority of exposure hours were recorded for men (exposure=6 534 538 hours), with the remainder covering women (exposure=309 924 hours), a mix of both (exposure=167 609 hours) or unreported/unclear (exposure=250 097 hours). Study characteristics are summarised in online supplemental tables S4 and S5.

Injury monitoring

Athletes were monitored for injury occurrences for a variety of periods, ranging from a single season to 13 seasons. Most studies (n=46) used a 'time-loss' definition of injury, that is, any medical disorder resulting from sport-related activity that caused absence or modified training or match play. The remaining studies defined injury as any physical or medical disorder (regardless of time loss, n=2), either time loss or medical disorders (n=2), medical disorder (n=1) or provided unclear/unreported definition of injury (n=12). To identify specific injuries, the majority (n=53) of the studies relied on medical or health practitioner diagnosis, with 4 using self-report, 1 using research assistant guided diagnosis, 1 using MRI and 4 providing unclear/unreported methods of diagnosis. Studies reported injuries to the hamstring (or 'posterior thigh') while others more specifically reported on hamstring strain injury. These two injury classes are summarised seperately (along with other details of the injury monitoring of each study) in online supplemental tables S4 and S5.

Incidence rates and prevalence

Hamstring injuries

The overall hamstring injury incidence rate was 0.81 per 1000 hours (95% CI=0.66 to 0.98; I^2=97%, k=102, injuries=5812, total exposure=7 029 654 hours, figure 2). Hamstring injury prevalence was calculated to be 13% (95% CI=9.5% to 17.6%; I^2=94%, k=51, injuries=1397, exposure=1 900 568 hours) for a prevalence period of 9 months. A significant effect for prevalence period was found (p=0.004), whereby the prevalence was found to increase by 1.13-fold (95% CI=1.04 to 1.23, figure 2C) of its value for a given month for each subsequent month of observation. Hamstring injuries were found to represent 10% of all injuries (95% CI=9% to 12%; I^2=87%, k=66, injuries=3352, total exposure=4 118 641 hours, figure 2D).

Moderators analysis revealed that hamstring injury incidence was not significantly different between sports (p=0.150 I^2=97%, k=102, injuries=5812, total exposure=7 029 654 hours, figure 2B), incidence rates did not change over time (p=0.269, I^2=97%, k=94, injuries=5700, exposure=6 844 785 hours, figure 3A), nor were incidence rates moderated by mass (p=0.542, I^2=91%, k=42, injuries=1711, exposure=2 166 431 hours, figure 3E) or stature (p=0.593, I^2=91%, k=42, injuries=1711, exposure=2 166 431 hours, figure 3F). However, a significant effect was found for age (p=0.003, I^2=94%, k=56, injuries=2512, exposure=3 164 072 hours, figure 3D), suggesting that the incidence of hamstring injuries increased by 6.4% (95% CI=2.2% to 10.8%) of the incidence for a given age for each year of increasing age. Additionally, hamstring injuries had a significantly greater incidence (p<0.001, I^2=90%, k=84, figure 3B) during match (incidence rate=3.85 per 1000 hours, 95% CI=3.04 to 4.89, injuries=1865, exposure=488 321 hours) compared with training (incidence rate=0.41 per 1000 hours, 95% CI=0.32 to 0.52, injuries=1131, exposure=2 854 095 hours) scenarios, and greater incidence (p<0.001, I^2=74%, k=10, figure 3C) on a grass surface (incidence rate=0.72 per 1000 hours, 95% CI=0.55 to 0.95, injuries=283, exposure=423 111 hours) compared with artificial turf (incidence rate=0.48 per 1000 hours, 95% CI=0.37 to 0.64, injuries=225, exposure=429 449 hours). Study inclusions in each meta-analytical model for hamstring injury is summarised in online supplemental table S6. For all meta-analytical models of hamstring injuries, results were robust when excluding low-quality studies (online supplemental table S7).

Hamstring strain injuries

The overall hamstring strain injury incidence rate was 0.67 per 1000 hours (95% CI=0.47 to 0.95; I^2=97%, k=41, injuries=2367, total exposure=3 398 412 hours, figure 4). Prevalence of hamstring strain injury was calculated to be 9.8% (95% CI=6.3% to 15.2%; I^2=86%, k=20, injuries=387, exposure=599 594 hours) for a prevalence period of 9 months. Prevalence period was not significantly associated with the estimated prevalence (p=0.888, figure 4C). Hamstring strain injuries were found to represent 9% of all injuries (95% CI=7% to 11%; I^2=90%, k=29, injuries=1907, total exposure=2 375 010 hours, figure 4D).

Moderators analysis revealed that hamstring strain injury incidence showed no significant effect for sport (p=0.133, I^2=98%, figure 4B), season (p=0.778, I^2=98%, k=39, injuries=2351, exposure=3 357 360 hours, figure 5A), age (p=0.363, I^2=96%, k=23, injuries=1127, exposure=1 465 486 hours, figure 5D), mass (p=0.829, I^2=95%, k=13, injuries=381,

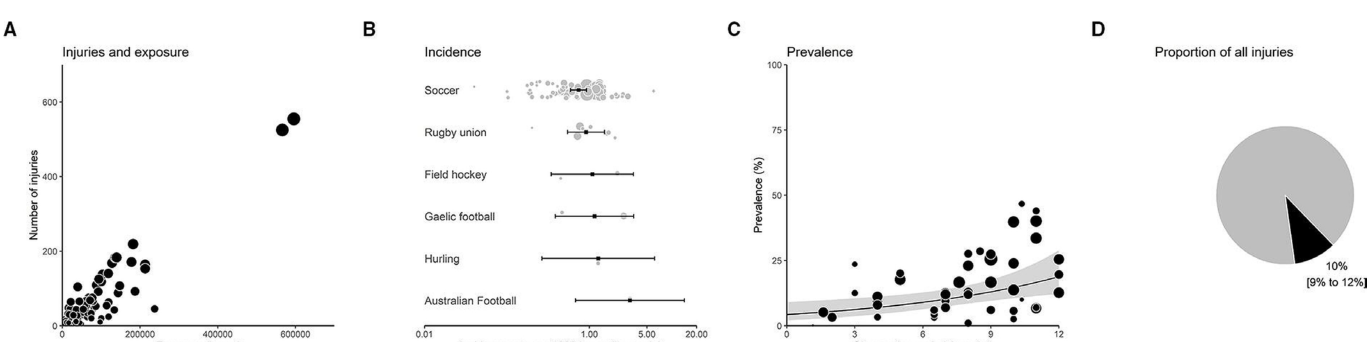

Figure 2 Results for hamstring injury meta-analysis. Panel (A) bubble plot of the number of injuries and hours of exposure for each cohort included in the analysis; (B) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) by sport; (C) pooled prevalence (black line) and 95% CI (grey shaded) and prevalence of each individual cohort (black bubbles) against the prevalence observation period; (D) hamstring injuries (black) as a proportion of all injuries (grey). For panels A-C, bubbles representing individual cohorts are sized according to their precision (ie, inversely to their SE).

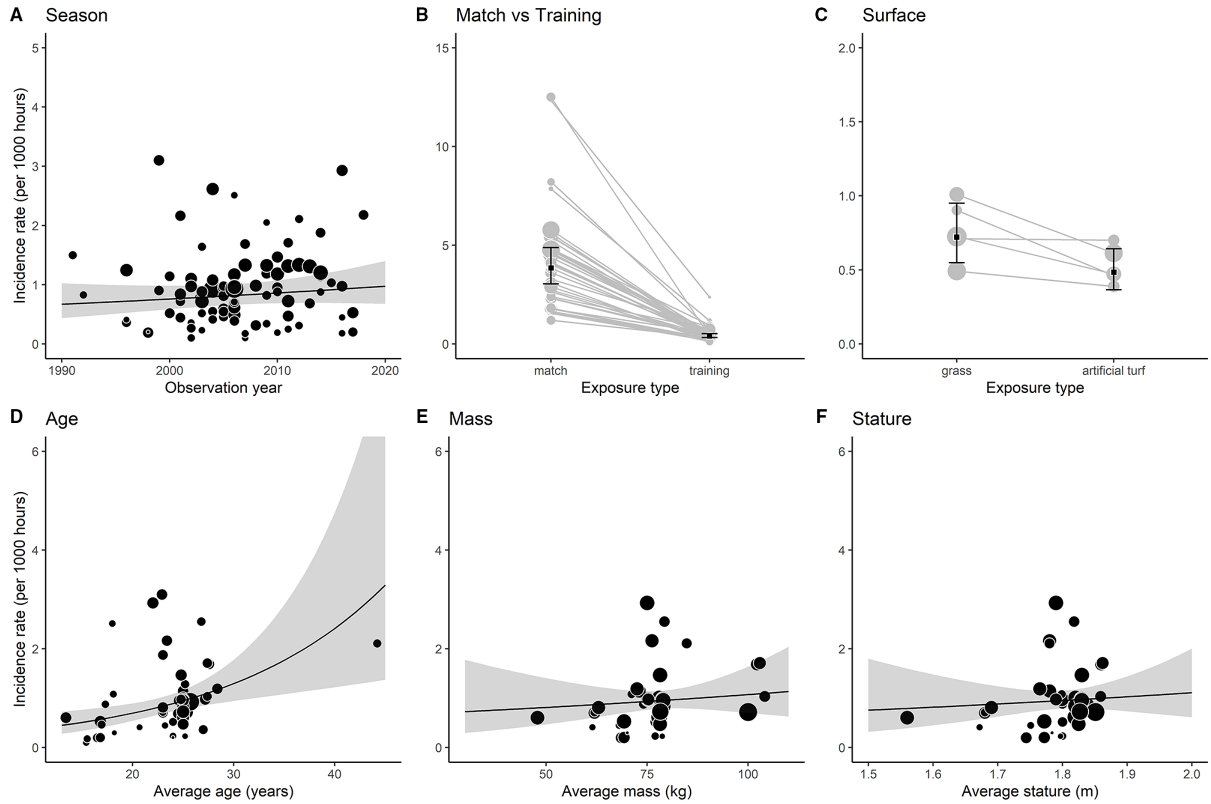

Figure 3 Moderator (meta-regression) analysis for hamstring injury incidence. Panel (A) pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the year of observation of each cohort; (B) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) for match and training situations; (C) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) for grass and artificial turf surfaces; (D) pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the average age of each cohort; (E) age-adjusted pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the average mass of each cohort; (F) age-adjusted pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the average stature of each cohort. For all panels, bubbles representing individual cohorts are sized according to their precision (ie, inversely to their SE).

exposure=546 771 hours, figure 5E) or stature (p=0.813, I^2=94%, k=13, injuries=381, exposure=546 771 hours, figure 5F). Hamstring strain injuries had a significantly greater incidence (p<0.001, I^2=87%, k=26, figure 5B) during match (incidence rate=3.57 per 1000 hours, 95% CI=2.17 to 5.87, injuries=297, exposure=117 514 hours) compared with training (incidence rate=0.43 per 1000 hours, 95% CI=0.26 to 0.71, injuries=233, exposure=769 888 hours), and greater incidence (p<0.001, I^2=78%, k=8, figure 5C) on a grass surface (incidence rate=0.72 per 1000 hours, 95% CI=0.49 to 1.06, injuries=176, exposure=275 640 hours) compared with artificial turf (incidence rate=0.49 per 1000 hours, 95% CI=0.33 to 0.72, injuries=171, exposure=315 255 hours). Study inclusions in each meta-analytical model for hamstring strain injury is summarised in online supplemental table S8. For all meta-analytical models of hamstring strain injuries, results were

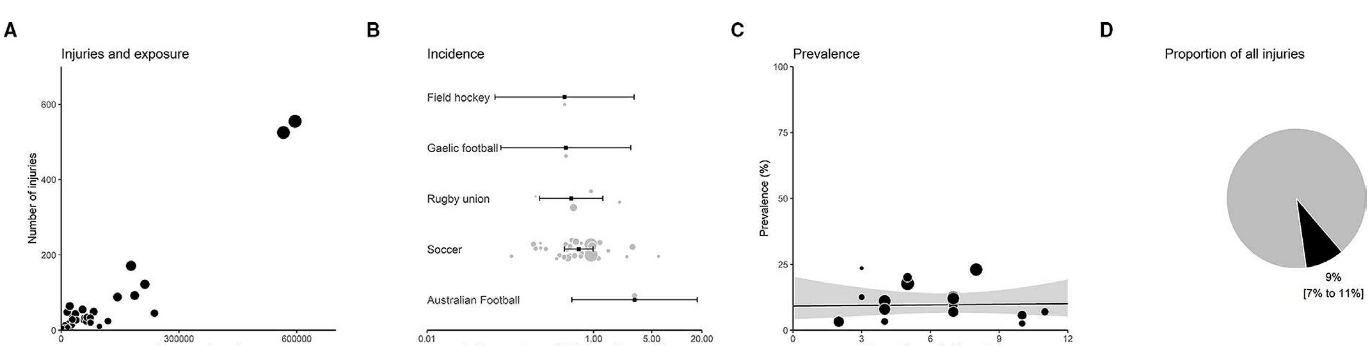

Figure 4 Results for hamstring strain injury meta-analysis. Panel (A) bubble plot of the number of injuries and hours of exposure for each cohort included in the analysis; (B) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) by sport; (C) pooled prevalence (black line) and 95% CI (grey shaded) and prevalence of each individual cohort (black bubbles) against the prevalence observation period; (D) hamstring injuries (black) as a proportion of all injuries (grey). For panels A–C, bubbles are sized according to their precision (ie, inversely to their SE).

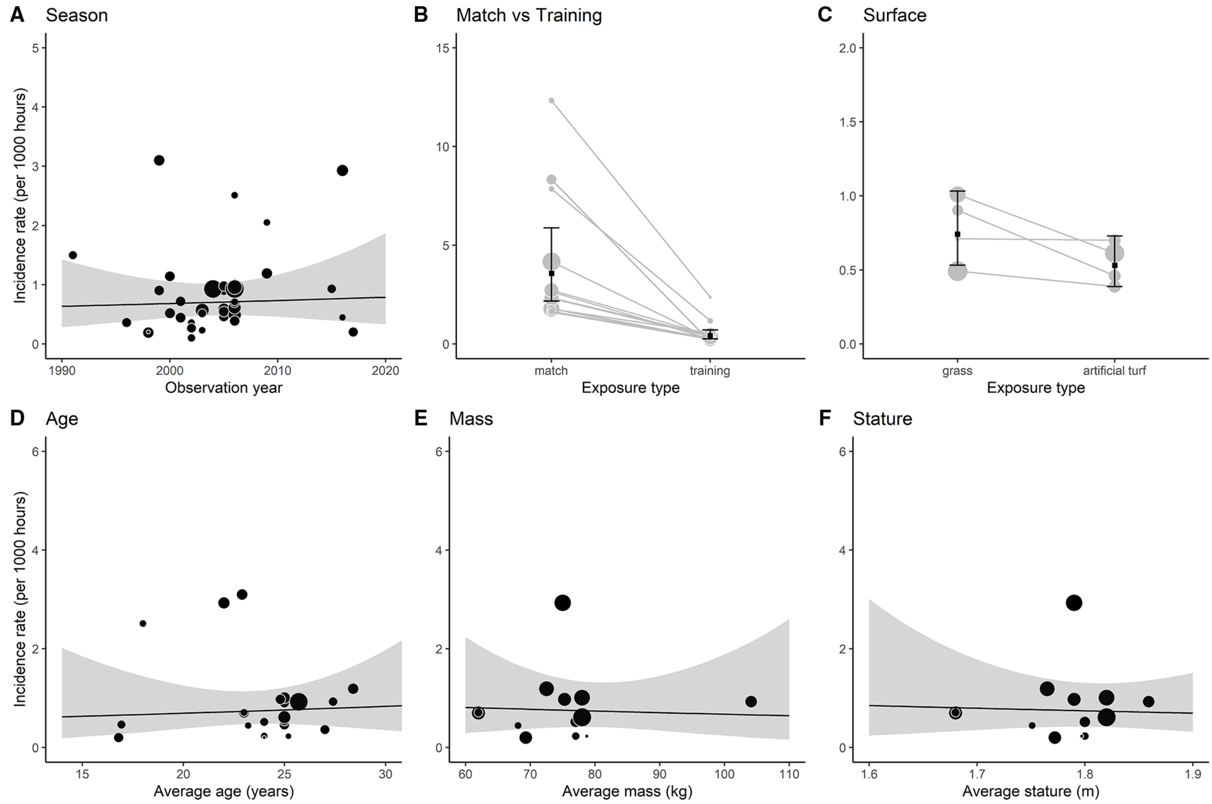

Figure 5 Moderator (meta-regression) analysis for hamstring strain injury incidence. Panel (A) pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the year of observation of each cohort; (B) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) for match and training situations; (C) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) for grass and artificial turf surfaces; (D) pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the average age of each cohort; (E) age-adjusted pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the average mass of each cohort; (F) age-adjusted pooled incidence (black line) and 95% CI (grey shaded) and incidence of each individual cohort (black bubbles) against the average stature of each cohort; (D). For all panels, bubbles representing individual cohorts are sized according to their precision (ie, inversely to their SE).

robust when excluding low-quality studies (online supplemental table S9).

DISCUSSION

This systematic review and meta-analysis provides the most comprehensive synthesis of hamstring injury incidence and prevalence in field-based team sports, including nearly 6000 injuries and over 7 million hours of exposure. We found that hamstring injury has an overall incidence rate of 0.81 per 1000 hours and prevalence of 13% over a 9-month period, while hamstring strain injury had an incidence rate of 0.67 per 1000 hours and a prevalence of 9.7% for a 9-month prevalence period. Secondary outcomes were that (1) hamstring injuries had a higher incidence in match compared with training scenarios and on grass surface compared with artificial turf; (2) hamstring injury incidence significantly increased by 6.4% for each year of increasing athlete age but age had no effect on the incidence of hamstring strain injury; (3) hamstring injury incidence has not significantly changed over the last 30 years; and (4) hamstring injury incidence was not significantly different between the included field-based team sports.

Completeness and quality of evidence

Although hamstring injury epidemiology has been widely researched, most studies have focused on a single sport (eg, soccer), often involving a single cohort (eg, team or league). The present analysis synthesises the data from 63 studies from six popular field-based team sports. Importantly, the included studies were conducted in over 19 countries, and included over 7 million hours of exposure, making our analysis of hamstring injury incidence substantially more comprehensive than previous work.

How many hamstring (strain) injuries can be expected in a season of field-based team sports?

Our analysis suggests that field-based team sports have a hamstring injury incidence of 0.81 per 1000 hours and a hamstring strain injury incidence of 0.67 per 1000 hours. To account for the observed heterogeneity in the pooled estimate, we computed the 95% prediction intervals, which estimates what can be expected in future settings involving the populations investigated. These were computed to be 0.18 to 3.70 per 1000 hours for hamstring injuries and 0.12 to 3.76 per 1000 hours for hamstring strain injuries. Based on the number of hours of exposure in a given season, clinicians can use this data to estimate the expected number of hamstring injuries and hamstring strain injuries for their athlete group.

Although we included multiple field-based team sports, hamstring injury and hamstring strain injury incidence was not significantly different between the field-based team sports included in our review. This result does not suggest that incidence rates are 'equivalent' between field-based team sports, largely because (1) data were not available (based on our eligibility criteria or otherwise) from all field-based team sports (eg, cricket, American football) and (2) most of the available data were from soccer and rugby union. Consequently, incidence rate estimates for other sports included in our analysis (field hockey, Gaelic football, Hurling and Australian Rules football) were characterised by greater uncertainty (figures 2 and 4), thus limiting comparisons between these sports.

Are incidence rates dependent on training and match situations or surface conditions?

Both hamstring injury and hamstring strain injury incidence was higher during competitive matches compared with training scenarios, which is consistent with other sports injuries.[85 86] Training situations may fail to replicate the greater high-intensity running demands of a match,[87 88] which plausibly contributes to the greater injury incidence in matches (running being a common mechanism of hamstring injuries[89]). Our analysis revealed lower incidence of hamstring injuries on artificial turf compared with grass surfaces in soccer, however, this finding needs to be interpreted with some caution given the relatively small number of exposure hours that have compared the incidence rate of hamstring injuries between grass (423 111 exposure hours) and artificial turf (429 449 exposure hours). Practically, surface exposure may not always be controllable at a training or match play level, depending on facility access. Surface type may interact with other injuries differently, and thus further research in a wide range of sports and other injuries (in addition to more work in hamstring injuries) is warranted.

Do athlete characteristics influence hamstring (strain) injury incidence rates?

We found the average age of each cohort significantly moderated the incidence of hamstring injuries, observing a 6.4% increase in hamstring injury incidence for every year of increasing athlete age. For example, our meta-analytical model estimates a hamstring injury incidence of 0.61 per 1000 hours (95% CI=0.45 to 0.83) for a youth team with an average player age of 18 years, while a senior team with an average age of 25 years would expect a higher incidence of 0.95 per 1000 hours (95% CI=0.78 to 1.16). A recent systematic review and meta-analysis also showed older athlete age to be a significant risk factor for hamstring strain injury.[14] The mechanism for increased age as a risk factor of hamstring injuries remains unclear, but older individuals are more likely to have had a previous injury, which is a well-established risk factor for subsequent injury.[14] However, we were not able to account for previous injury in our models, as studies did not report sufficient data for this analysis. It should be noted that there was no significant effect of age on the incidence of hamstring strain injury, which may suggest that the increased incidence in hamstring injury with increasing age is due to a greater occurrence of injuries other than hamstring strain injuries. However, based on the data presented in our review this assertion is speculative and future investigation would be required to further elucidate which specific hamstring injuries show a propensity for greater incidence in older individuals.

Other participant characteristics such as mass and stature have not been shown to be related to risk of hamstring (strain) injury[14] and we also found no significant relationships with hamstring injury or hamstring strain injury incidence. We also found a notable lack of studies including both men and women. Studies that include both men and women are critical for subgroup comparisons in meta-analysis, as they can better control for other factors (eg, different sports, competition level) that can otherwise confound results. We strongly urge future studies to include (or specifically focus on) female participants to better understand the incidence of hamstring injuries.

Are we moving in the right direction?

Numerous studies have evaluated risk factors[14 90 91], preventative training interventions[92 93] and rehabilitation[94 95] for hamstring injuries, all to lower their overall incidence and burden. Despite this research, our analysis revealed that the incidence of hamstring injuries or hamstring strain injuries have not changed over the last 30 years. Although this may suggest that strategies that are more effective at reducing incidence are warranted, effective protocols (such as those including the Nordic hamstring exercise) do exist[93] but suffer from low compliance.[96] Our results may also add to preventative efforts, suggesting that more work understanding why older athletes have a greater incidence of hamstring injury (but not hamstring strain injury) is warranted, while preventative efforts may need to focus on the demands or mechanisms of injury during match play.

LIMITATIONS

First, our search strategy may not have retrieved all relevant articles and included studies did not always report sufficient data to maximise their use in our analysis. For example, multiple season data was often reported as a single representative value (ie, total number of hamstring injuries and exposure hours over the entire period), which may have diluted our analysis of hamstring injury incidence over time. We recommend future studies maximise the intricacy of reported data and report important moderators (eg, age) where possible.

Second, the retrieved literature used similar, but not identical, terminology to describe the pathology of interest. Hamstring injury, hamstring strain injury and posterior thigh injury were used to varying degrees across the literature. This was not anticipated by the research team (our registration documentation referred to hamstring injury only) and this required us to make further considerations during the study selection phase to article eligibility. We deemed it appropriate to combine data from studies using all three terms, but this approach is not without limitations. Furthermore, even though studies may have described the pathology using the same terminology (eg, multiple studies referring to hamstring strain injury) this does not mean that they used an agreed and universal definition for this term. Variations between studies in the definitions of the same injury description (ie, hamstring injury, posterior thigh injury, hamstring strain injury) was unable to be accounted for the current article and should be considered a limitation.

We also acknowledge that the risk of bias cannot be completely avoided. However, we did perform an assessment of methodological quality, revealing low methodological quality for 20 studies.[25 27 31 36 41 42 44 51 52 56 62 64 67 68 71 73–75 82 83] These studies received this classification mainly due to a lack of clear inclusion and exclusion criteria, not controlling for potential sources of bias (eg, previous history of injury) and not providing a grading of injury. While our analysis showed that exclusion of these low-quality studies did not alter any of our results (online supplemental table S7 and S9), we recommend that future studies consider these methodological factors to improve quality.

CONCLUSIONS

The incidence of hamstring injury is 0.81 per 1000 hours, representing 10% of all injuries in field-based team sports. Injury incidence increased with older athlete age, in match scenarios (compared with training) and on grass surface (compared with artificial turf). Incidence was not moderated by body mass or stature, and importantly, has not changed over the last 30 years. Our findings suggest that more work is needed to reduce the incidence of hamstring injury in field-based team sports.

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Correction:*Incidence and prevalence of hamstring injuries in field-based team sports: a systematic review and meta-analysis of 5952 injuries from over 7 million exposure hours*

Maniar N, Carmichael DS, Hickey JT, *et al*. Incidence and prevalence of hamstring injuries in field-based team sports: a systematic review and meta-analysis of 5952 injuries from over 7 million exposure hours. *British Journal of Sports Medicine* 2023;57:109-16.doi:10.1136/bjsports-2021-104936

Typographical errors were discovered in the analysis code pertaining to two outcome measures: prevalence and proportions. Correction of these errors result in minor changes to data reported in the results, figures 2 and 4, and some elements of online supplemental material. Our primary outcome variables (related to injury incidence) were unaffected by the error and note that the impact on the affected outcomes (prevalence and proportion) are minor and do not change the conclusions of the article (table 1). Corrected versions of figures 2 and 4 and affected online supplemental material are also provided, noting that in these items, only data related to injury prevalence and proportion are affected by the correction.

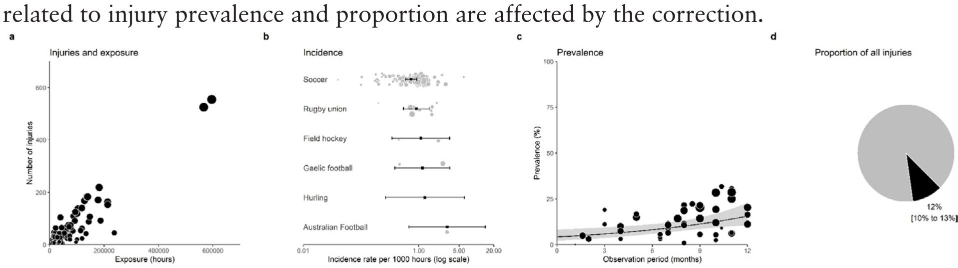

Figure 2 Results for hamstring injury meta-analysis. Panel (a) bubble plot of the number of injuries and hours of exposure for each cohort included in the analysis; (b) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) by sport; (c) pooled prevalence (black line) and 95%CI (grey shaded) and prevalence of each individual cohort (black bubbles) against the prevalence observation period; (d) hamstring injuries (black) as a proportion of all injuries (grey). For panels a-c, bubbles representing individual cohorts are sized according to their precision (i.e., inversely to their SE).

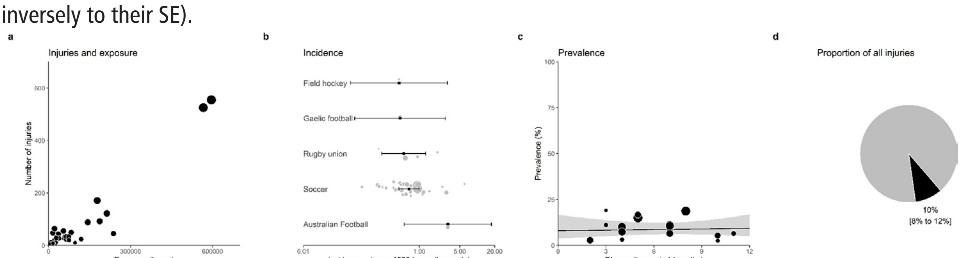

Figure 4 Results for hamstring strain injury meta-analysis. Panel (a) bubble plot of the number of injuries and hours of exposure for each cohort included in the analysis; (b) pooled incidence (black square) and 95% CI (black error bars) and incidence of each individual cohort (grey bubbles) by sport; (c) pooled prevalence (black line) and 95%CI (grey shaded) and prevalence of each individual cohort (black bubbles) against the prevalence observation period; (d) hamstring injuries (black) as a proportion of all injuries (grey). For panels a–c, bubbles are sized according to their precision (i.e., inversely to their SE).

Table 1 Summary of corrections to estimate of the prevalence of hamstring and hamstring strain injury (HSI) prevalence and their proportion of all injuries.

	Estimate	95%CI (lower)	95%CI (upper)	I^2	Coefficient	95%CI (lower)	95%CI (upper)	P
Hamstring injury prevalence								
Published	13.0%	9.5%	17.6%	94%	1.13	1.04	1.23	0.004
Corrected	11.3%	8.6%	14.9%	95%	1.11	1.04	1.20	0.004
Hamstring injury proportion								
Published	10%	9%	12%	87%	–	–	–	–
Corrected	12%	10%	13%	90%	–	–	–	–
HSI prevalence								
Published	9.8%	6.3%	15.2%	86%	1.01	0.91	1.12	0.888
Corrected	8.9%	6.0%	13.4%	87%	1.01	0.92	1.11	0.803
HSI proportion								

	Estimate	95%CI (lower)	95%CI (upper)	I^2	Coefficient	95%CI (lower)	95%CI (upper)	P
Published	9%	7%	11%	90%	–	–	–	–
Corrected	10%	8%	12%	92%	–	–	–	–

CI, confidence interval; .

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