Title: Differences In Injury Profiles Between Female And Male Athletes Across The Participant Classification Framework: A Systematic Review and meta-analysis

Running title: Injury profiles for male and female athletes

Authors: Natalie J. Hardaker,[1,2] Patria A. Hume,[1,3,4] Stacy T. Sims[1,5]

[1]Sports Performance Research Institute New Zealand (SPRINZ), Faculty of Health and Environmental Science, Auckland University of Technology, New Zealand
[2]Accident Compensation Corporation, Wellington, New Zealand
[3]Auckland Bioengineering Institute, The University of Auckland, Auckland, New Zealand
[4]Tech & Policy Lab, Law School, The University of Western Australia, Perth, Australia
[5]Stanford Lifestyle Medicine, Stanford University, Palo Alto, CA, USA

Correspondence to:
Natalie Hardaker
Sport Performance Research Institute New Zealand, Auckland University of Technology
Tel: +64 (04) 816 7174
Email: Natalie.Hardaker@aut.ac.nz

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Abstract

Background Female sex is a significant determinant for ACL injury. It is not understood if sex is a key determinant for other sports related injuries.
Objective To identify where differences in injury profiles are most apparent between the sexes in all sports across the 6-tiered participant classification framework.
Methods This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and the 'implementing Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science (PERSiST) guidance. The databases, PubMed, CINAHL, Web of Science SPORTDiscus, Medline, Scopus, Cochrane Library and EBSCO were searched from inception to 24 April 2023. Longitudinal, prospective, and retrospective cohort studies, cross sectional and descriptive epidemiology studies that used standard injury data collection were included. Studies were excluded if injuries were not medically diagnosed and if injuries were not reported and/or analysed by sex. Two reviewers independently extracted data and assessed study quality using the Downs and Black checklist.
Results Overall 180 studies were included (8 tier-5, 40 tier-4, 98 tier-3, 30 tier-2, 5 tier-1 studies; one study included data in two tiers). Of those, 174 studies were of moderate quality and six studies were of limited quality. In sex comparable sports, there was moderate evidence that female athletes had greater risk of knee injury (RR 2.7; 95% CI 1.4-5.5), foot/ankle injuries (RR 1.25; 95% CI 1.17-1.34), bone stress injury (RR 3.4; 95% CI 2.1-5.4) and concussion (RR 8.46; 95%CI 1.04-68.77) than male athletes. Male athletes were at increased risk of hip/groin injuries (RR 2.26; 95% CI 1.31-3.88) and hamstring injuries (RR 2.4; 95% CI 1.8-3.2) compared to females, particularly in dynamic sports. Male athletes were 1.8 (1.37-2.7) to 2.8 (2.45-3.24) times more likely to sustain acute fractures than female athletes, with the highest risk in competition.
Discussion Most studies in all cohorts were of moderate quality (mean/range of scores tier-5 17±2.2{14-20}, tier-4 16.9±1.9{11-21}, tier-3 16.9±1.5{11-20}, tier-2 16.3±2.2{11-20}, tier-1studies 15.6±1.3{14-17} out of 28 on the Downs and Black checklist), with only six studies of limited quality. Female athletes' propensity towards bone stress injuries highlights opportunities to reinforce development of optimal bone health during adolescence and to outline the effects of energy availability. Earlier strength development and exposure to neuromuscular training programmes and modification of skill development in female athletes may be effective strategies in reducing lower limb injury risk. Key components of neuromuscular training programmes could be beneficial in reducing hip/groin and hamstring injury risk in male athletes. There may be a need for sex specific prevention and return to sport protocols for sports related concussion in female athletes.
Conclusions Female sex was a key determinant for sports related injuries beyond ACL injury and included foot/ankle injury, bone stress injury and sports related concussion. Male sex was a key determinant in hip/groin, hamstring injury and upper limb injury.

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1 Introduction

Title IX is the federal civil rights law in the United States that was enacted as part of the Education Amendments of 1972. It prohibits sex-based discrimination of any education program that receives funding from the federal government and was pivotal in increasing the opportunities for females to participate in sport and exercise [1]. Sport is now a viable career option for female athletes and Tokyo 2021 was the first gender equal Olympic Games with females comprising 49% of participants and parity of medals available for male and female athletes[2]. In parallel with increasing participation of females in sport, a disproportionate increase in ACL injury has been observed, particularly in sports that involve rapid deceleration, change of direction or jump-landing movements [3-6]. Female athletes have 4-10 times increased incidence of non-contact ACL injury [5-7]. There is a significant body of evidence supporting the understanding of ACL risk profiles in female athletes [3-5, 8-10] and the development of effective primary prevention programmes. Alterations in biomechanics, muscle strength, and neuromuscular control that females experience at the onset of puberty are different to those observed in males, these divergent changes may contribute to an increased susceptibility to ACL injury [4, 9, 10]. It is plausible that these and other factors create sex specific injury profiles across sport, but this has not been thoroughly investigated. Injury is a barrier to participating in training and/or competition, therefore understanding injury patterns across sport will contribute to the development of effective, targeted interventions to minimise the risk of injuries and support athletes in maintaining consistent participation in sport and exercise. Bittencourt's [11] complex systems approach for sports injuries moved risk factor identification to injury pattern recognition. The identified features of complex systems include relationships (interactions) among determinants, and regularities (profiles) that characterise emerging injury patterns. Sex is considered a contributing unit in the web of determinants. Throughout this review the term 'sex' is used to refer biological sex. That is sex assigned at birth, which is self-reported, and therefore it is assumed that athletes included in the studies of this review are unlikely to have undergone sex verification.

The aim of this review was to investigate original studies and identify where differences in injury profiles are most apparent between the sexes in all sports across the 6-tiered (0-5) athlete classification framework. [12] For greater accuracy and to avoid recall bias, this review focused on medically diagnosed injuries (i.e., self-report injuries were excluded). Due to the volume of research in ACL injury mechanisms, risk and prevention [3-10, 13-16], ACL injury was excluded from the current review.

2 Methods

The protocol for this review was pre-registered on Prospero; CRD42017058806 (last updated on 7th June 2023).

2.1 Literature Search Methodology

The PRISMA guideline [17] review methodology (literature search; assessment of study quality; data collection of study characteristics; analysis and interpretation of results; recommendations for practice and further research) and the 'implementing Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science (PERSiST) guidance was used to evaluate the effects of sex on injury profiles in sport.

2.2 Search Strategy

PubMed, CINAHL, Web of Science SPORTDiscus, Medline, Scopus, Cochrane Library and EBSCO databases were searched for terms linked with Boolean operators ('AND', 'OR'): 1. Gender OR Sex OR Male OR Female; 2. Sport* OR athlet* OR player; 3. Injur* OR "overuse injur*" OR "injury prevention" OR intervention; 1 AND 2 AND 3 in full text and English. Searching was from inception to 24 April 2023. Manual searching of reference lists and the 'Cited by' tool on Google Scholar were used to identify additional articles.

2.3 Study Selection

Titles and abstracts of potentially eligible studies were screened by lead author (NH) with a 10% check by co-authors (PH and SS). Full text of all studies that were not excluded after initial title and abstract screening were retrieved and assessed for eligibility by lead author (NH) and independently checked by a co-author (PH). Disagreements between researchers during full-text screening were resolved through discussion with a third co-author (SS).

A study was considered eligible if it met the inclusion criteria provided in Table 1. Studies were included if: (i) injury rate and/or injury incidence was reported or analysed by sex; (ii) injury reporting was standardized (i.e., there was a consistent system in place for recording/documenting injuries; (iii) injury rate per player or injury incidence per athletic exposures and/or injury rate ratios were reported. Papers were excluded if: (i) content was unavailable in English; (ii) content was unavailable in full text format; (iii) data collection was through self-report and/or injury was not medically diagnosed; (iv) the study did not provide additional information for any of the identified sections and subsections of this review. Figure 1 shows the flow of information through the systematic review.

2.4 Injury Definition

Acute and overuse/chronic injuries were included if sustained due to sports participation and if they were defined as requiring attention from a healthcare professional that resulted in diagnosis. Injuries were reported as per original data which included incidence rates (i.e., injuries per training and competition exposure hours or per total athlete exposures [AEs]) or prevalence (i.e., number of injuries per registered athlete or, percentage of registered athletes).

2.5 Athlete Classification

All participants in eligible studies were considered 'athletes' and were classified according to the tiered system presented by McKay et al. [12]. Tier-0 is defined as 'sedentary' with criteria "do not meet minimum activity guidelines and undertake occasional or incidental physical activity" (46% of the global population). Tier-5 is defined as 'World class' with criteria "Olympic and/or world medalists, world-record holders and athletes achieving within 2% of world-record performance and/or world leading performance, top 3-20 in world ranking, maximal or near maximal training within the given sport norms and exceptional skill level" (0.00006% of global population). Within this classification system, data relating to adolescent athletes has been sub-categorised due to the unique aspects of the developing musculoskeletal system.

2.6 Data Extraction

Lead author (NH) extracted data from included studies; data were checked by a co-author (PH) and conflicts resolved after discussion with the third co-author (SS). Data extraction included study design, participant numbers and characteristics (age, sex, BMI), and study characteristics (data collection methods, type of injury, sex differences, type of sport, injury incidence rate [IIR], injury rate [IR], relative risk [RR], incidence rate ratio [IRR] or injury rate ratio with confidence intervals [CI]). As a result of extracting data, it was clear that studies reported analysis for fractures and overuse injuries by sex, therefore analyses for fractures and overuse injuries are provided as types of injuries in addition to body site analyses.

2.7 Assessment of Study Quality

Studies identified for final inclusion were observational in nature and were therefore analysed using the modified Downs and Black checklist [18] that has good validity, test-retest and interrater reliability for methodological quality of randomised control trials [RCT] and non-RCTs. The Downs and Black checklist considered methodological quality of each study irrespective of the number and type of different outcomes assessed in each study. The modified Downs and Black checklist of 27 questions (outlined in Supplementary Table S1) related to quality of reporting (ten questions, with one question carrying 2 points), external validity (three questions), internal validity–bias (seven questions) and internal validity–confounding (six questions), and statistical power (one question). In the modified version the scoring of item 27 that rates whether the study performed a power calculation or not was changed from a score out of five to a score out of one to ensure consistent scoring across studies (zero points awarded if no power calculation was attempted, and one point awarded if a power calculation was described). On the reporting item the 'intervention' in this context was the data collection method described in studies. Similarly, in item four addressing 'compliance with the intervention', this was applied to the data collection method. The maximum possible score for the modified

Downs and Black was 28. Two authors (NH, PH) reviewed all included studies and SS also independently reviewed a randomly selected 10% of studies. With comparison of scoring between co-authors, any scores that differed were discussed at the conclusion of the review process and a final designation of the score agreed by consensus. There were disagreements between researchers (NH and PH) on two papers, which were resolved through discussion with the third co-author (SS). As there were only two cases of ratings being different, kappa analysis was not reported. Each study was given a methodological quality index categorization [18] using the modified Downs and Black questions: poor (<7/28 with <25%), limited (8-13; 25-49%), moderate (14-21; 50-74%), or strong (21+; 75%+). If a study was of 'poor' or 'limited' quality; consideration was given to the direction of the effect reported. Greater weight was placed on moderate quality studies when drawing conclusions, if a single 'poor' or 'limited' quality study ran contrary to most of the moderate quality studies, those data were excluded from the key findings.

Meta-analyses by body site and injury type were conducted to calculate pooled fixed effects (Mantel-Haenszel method for dichotomous data) using RevMan 5.3 software. Analyses were completed where data collection and reporting methods were similar and allowed RR to be calculated. A pooled estimate for the IRR was calculated for each outcome with two or more studies and summarized in a forest plot. Heterogeneity was assessed using the I^2 statistic (>60% considered to represent substantial heterogeneity; >75% considerable heterogeneity). Where an outcome had an I^2 value between 30-60%, a random effects model was used to cope with the moderate heterogeneity. For any outcomes that had an I^2 value greater than 75%, the meta-analysis was excluded due to substantial heterogeneity as per the Cochrane guideline [19].

3 Results

3.1 Studies Extracted

A total of 26,448 studies were identified, 1,438 were duplicates and were removed. A further 23,468 studies were removed after screening by title and 1,031 removed after screening by abstract. After eligibility assessment of 551 full text articles, 375 additional studies were excluded due to: 1) full text not available (n=13); 2) not relevant/did not answer research question (n=141); 3) did not include sex analysis or injury rates (n=166); or 4) injuries were not medically diagnosed (n=47). A further eight studies were duplicates identified manually and excluded. Data from 180 studies were included in this review for analysis (Figure 1). Table 2 outlines studies that showed significant, or not, sex differences for overall (all injury types combined) injury rates across the classification framework. It is to be noted that the total number of studies reported in some tables adds up to 181 as one study [20] included data for two different tiers. Table 3 reports studies that showed significant, or not, sex differences by injury location.

3.2 Study Methodological Quality

Final quality rating (mean modified Downs and Black) scores are reported for studies in Tables 4-8 (individual criteria scores are in Supplementary Table S2). Quality rating scores (mean±SD; range) were highest for tier-5 (17±2.2; 14-20), followed by tier-4 (16.9±1.9; 11-21), tier-2 (16.3±2.2; 11-20), tier-3 (16.9±1.4; 11-20) and tier-1 (15.6±1.3; 14-17). All studies clearly described their objectives and outcomes. Studies of limited quality were included in the results if they reported similar trends to the moderate quality studies. No studies were excluded on this basis. Risk of bias was initially assessed using the Risk of Bias In Non-randomized Studies - of Exposure (ROBINS-E) tool. The preliminary analysis questions in the ROBINS-E suggested that all studies could be considered at "high risk of bias" therefore no further detailed domain based RoB assessment was carried out. Internal validity scores in the Downs and Black checklist ranged from two to five out of a possible seven (Supplementary table S1).

3.3 Injury Data Collection, Definitions and Rates

Injury data collection methods included injury report forms [21-63], clinical records [64-83], insurance scheme data [84-86] and national online injury surveillance systems [20, 24-26, 87-165]. Data collection periods varied from a single tournament to 20 years.

3.5 Athlete classification

Of 180 studies assessed, eight studies included tier-5 athletes [26, 27, 32, 49-52, 76] (Table 4), 40 studies included tier-4 athletes [20-26, 28-31, 33, 36, 37, 40, 48, 53-58, 75, 77-79, 102, 110, 111, 113, 134, 135, 137, 138, 166-171] [20, 87-113] (Table 5), 98 studies included tier-3 athletes [20, 34, 35, 42, 44-47, 59-61, 66, 67, 71, 74, 80, 88-109, 112, 113, 118-124, 127-133, 136, 139-152, 172-189] (Table 6), 30 studies included tier-2 athletes [39, 43, 62, 63, 65, 68-70, 72, 81-83, 86, 125, 126, 153-162, 190-194] (Table 7), and five studies included tier-1 athletes [84, 85, 163-165] (Table 8).

3.6 Study Participant Characteristics and Sports

Tier-5 studies (Table 4) provided data for rowing, martial arts, aquatic sports, gymnastics, winter sports and team-based ball sports. All studies presented season data and investigated senior athletes. Sample sizes ranged from 24 to 2,567 athletes and age ranged from 19-24 yrs. Within these studies, females represented 40-50% of participants and 43% of the total 3,243 athletes across all studies.

Tier-4 studies (Table 5) provided data for tennis, martial arts, athletics, ballet, cricket, triathlon, aquatic sports, gymnastics, winter sports and team-based ball sports. Data were collected through the season and during tournaments. Sample size for tier-4 studies ranged from 42 to 17,101 athletes with age ranging from 11-35 yrs. Within these studies, females represented 35-62% of participants and 46% of the total 45,472 athletes across all studies.

Tier-3 studies (Table 6) provided data for rowing, martial arts, aquatic sports, equestrian, military recruits, mountain biking, tennis, athletics, badminton, and team-based ball sports. Ninety-four studies presented through season data and four studies presented tournament data. Forty-three studies investigated senior athletes, forty-nine studies adolescent athletes and six studies include data combined from adolescent and senior athletes. Thirty-four studies in tier-3 athletes reported participant characteristics (sample size ranged from 49 to 358,319 athletes with age ranging from 11-40 yrs. Within these studies, females represented 18-91% of participants and 22% of the total 985,186 athletes across all studies. Studies that did not report sample size did report injury data consistent with methods of this review.

Tier-2 studies (Table 7) reported injury data from running, martial arts aquatic sports [72], gymnastics [86], winter sports, CrossFit, wrestling, dance, cycling and mountain biking, and team-based ball sports. Tier-2 included data from senior athletes and adolescent athletes. Data were collected through season and during tournaments. Data from over 45,281 female athletes and 96,027 male athletes (32% female) were included. Tier-1 data (Table 8) included multiple different recreational sports, and all data were from injuries occurring throughout the year. Studies included senior athletes and adolescent athletes. Tier-1 studies did not report sample sizes but reported injury data consistent with methods of this review. Across the tier-1 studies data for a total of 641,582 injuries were reported with 27% from females.

3.7 Studies with Sex Specific Injury Location Diagnoses

Analyses in cohorts from 'sex comparable' sports (males and females playing by the same rules) revealed sex-specific injury profiles. There was moderate evidence that female athletes were at increased risk of knee (RR 2.7 95% CI 1.4-5.5), foot/ankle (RR 1.25 95% CI 1.2-1.3 to RR 8 95% CI 1-63), bone stress injury (RR 3.4 95% CI 2.1-5.4) and sports related concussion (RR 1.3 95% CI 1.0-1.8 to RR 8.5 95%CI 1-69). Conversely, male athletes had 1.4 (95% CI 1.3-1.6) to 2.3 (95% CI 1.3-3.9) times increased risk of hip/groin injuries and 2.4 (95% CI 1.8-3.2) times greater risk of hamstring injury than female athletes, particularly in sports that are explosive in nature. Male athletes were also 1.8 (95% CI 1.4-2.7) to 2.8 (95% CI 2.5-3.2) times more likely to sustain acute fractures than female athletes, particularly in competition. Table 3 outlines studies by injury location and tier.

3.7.1 Lower extremity

Three moderate quality studies [25, 74, 167] showed a significantly higher rate and incidence of lower limb injury in male athletes in athletics (male 22±3.4 v female 16.2±3.2 injuries/1,000 registered athletes) [25] (tier-4), football (soccer) (male 7.3 v female 5.8/1,000 player hours) [167] (tier-4) and mixed martial arts (male 8/100 v female 2/100 AE)[74] (tier-3). Ten moderate quality studies [27, 53, 56, 71, 83, 104, 108, 124, 157, 161] across all tiers of the participation pyramid showed that a higher proportion of female injuries are to the lower limb and one study across multiple sports in adolescents [173] showed that lower limb injuries were 1.5 times (RR 1.5, 95% CI 1.12-2.15) more likely to be season ending in female athletes. This was driven by knee ligament injuries resulting in surgery, particularly in football (knee surgery Injury Proportion Ratio [IPR] 3.57 [95% CI; 1.20-10.6]).

Hip/groin

Nine studies [25, 28, 32, 93, 99, 142, 167, 169, 170] of moderate quality showed a significantly higher rate and incidence of hip/groin injury in male athletes in athletics [25] multiple team based sports [28, 32, 93, 99, 142, 167, 169, 170], gymnastics [93, 99] and tennis [93, 99]. There was moderate quality evidence [28, 93, 133] that in male athletes, a greater proportion of overall injuries were to the hip/groin region; IPR 1.07 (95% CI, 0.73-1.56)[93], 3.27 (95% CI, 1.70-6.28)[133] and the risk of hip/groin injury in male athletes was 1.41 (95% CI 1.28 to 1.55) [99] to RR 3.01 (95% CI 1.54 to 5.87)[195] greater than female athletes in similar sports. Five studies [71, 188] reported higher rates of hip/groin injuries in female athletes ([female 6.7% vs male 3.7%], [female 7.1% vs male 3.8%] and female 50% vs male 6.7%]); these data were specifically related to overuse/gradual onset injuries in adolescent (tier-3) athletes [71, 188] and recreational runners [82] and acute injuries in basketball (tier-3) [142] and Crossfit (tier-2) [83]. The meta-analysis of 11 studies for hip/groin showed an overall significant RR of 1.30 [1.21-1.40] for males, however showed considerable heterogeneity (I^2=89%) across studies (Supplementary Figure S1).

Hamstring

Male athletes were up to 2.42 times [90] more likely to sustain hamstring injury than female athletes. Moderate quality evidence across eight studies for team [25, 35, 89-91, 167] and individual sports [38, 89, 174] consistently showed male athletes to have a higher rate and incidence of hamstring injuries. The highest incidence and rate of hamstring injury was reported in (tier-4) male football players (male 1.52 vs female 0.79/1,000 player hours) [167] (tier-4) track and field athletes (male 22.4±3.4 vs female 11.5±2.6 injuries/1000 registered athletes respectively [38]. No studies reported a higher rate or incidence of hamstring injury in female athletes. The meta-analysis of five studies for hamstring injuries showed an overall significant RR of 1.67 [1.48-1.88] for males (Figure 2).

Knee injury

Dependent on sport, female athletes had up to 2.72 times (RR 2.72 [95% CI 1.35-5.51]) [134] increased risk of knee injury. Moderate quality evidence across nine studies [81, 85, 108, 121, 122, 128, 134, 167, 188] showed a significantly higher rate of knee injury in female athletes, with the highest rates reported in elite skiers (female 10.1 v male 3.7 injuries/100 athletes/season) [134]. Three studies [108, 122, 188] reported a higher incidence of patellofemoral pain with an incidence rate of up to 19.35/100,000 AEs (vs 14.15 in males) and the highest prevalence in female outdoor track, field hockey, lacrosse and softball [108]. Knee injuries accounted for a greater proportion of overall injury burden in (tier-3) adolescent female athletes (IPR knee 1.3, 95%CI; 1.11-1.53) [128] (female 16.7% v male 5.9%)[139] and in higher performance female athletes (knee ligament injury; male 3%, female 9%; $p<0.05$) [167]. Further, one study [162] (tier-2) in children and adolescents highlighted that the relative increase in prevalence of knee injuries from childhood to adolescence was greater in females than it was in males. The meta-analysis of 14 studies for knee injuries showed an overall significant RR of 1.61 [1.39-1.86] for females (Figure 3).

Foot/ankle injury

The risk of foot/ankle injury was 1.25 (RR 1.25, 95%CI 1.17 to 1.34) [129] to 7 times (RR 7.95, 95% CI 1.00 to 63.1) [26] greater in female athletes compared to male athletes in the same sports. This pattern was consistent in 12 moderate quality studies across the participation pyramid [26, 43, 57, 62-64, 110, 129, 137, 141, 182, 192]. Incidence rates were highest in basketball competition (9.45/10,000 AE's) and gymnastics competition (9.36/10,000 AE's)[129] and football (2.83/1,000 hrs) [63]. One study specifically highlighted female non-contact ankle IRR 2.78 (95% CI 1.91–4.02) [63]. Three moderate quality studies [20, 101, 109] reported significantly higher rates of ankle injury in male athletes specifically in basketball [101, 109], ice hockey [101] and running [20, 82], in addition, one study [141] across multiple sports reported that foot injuries in male athletes were more likely to result in surgery (RR 2.43; 95% CI 1.71-3.44) or to be season ending (RR 1.89; 95% CI 1.48-2.41) than was observed in female athletes. One study in taekwondo [52] reported no significant sex difference in foot and ankle injuries but there was a trend towards IIR being higher in male athletes. The meta-analysis of 17 studies for ankle injuries showed an overall significant RR of 1.20 [1.09-1.33] for females (Figure 4).

3.7.2 Upper extremity

There was moderate quality evidence in 20 studies [44, 53, 65, 71, 81, 83, 97, 100, 102, 103, 117, 136, 139, 144, 157, 160, 164, 179, 185, 188] of a significantly higher incidence of upper limb injuries in male athletes in different sports and across all tiers of the participation pyramid. The highest IIR in specific sports were 54.64/1,000 AEs (versus female 42.64) in adolescent judo [44] and 6.40/10,000 AE's (versus female 2.12) in NCAA ice hockey [97]. One study in adolescent athletes [136] across multiple sports reported male athletes to be at 2.38 (95% CI 1.32-4.55) times increased risk of upper limb injuries compared to female athletes. More specifically, two studies reported that male athletes were at increased risk of shoulder injuries in sex comparable sports (RR 4.67 [95% CI 3.56-6.14]) [97] and in water polo (RR 3.0 [95% CI 1.3-7.0]) [152]. Four moderate quality studies [54, 63, 134, 142] reported that female athletes had a higher rate of upper limb injury. These studies included softball, canoe-kayak, rowing, sailing, swimming, tennis, triathlon, fencing, bi-athlon, judo, snowboarding [54], football (shoulder injuries male 0.04/1000h football vs female 0.16/1000h; male IRR 0.24 [95% CI 0.09–0.65]; p=0.005) [63], skiing [54, 134] and wrestling (shoulder injury female 62.5% vs male wrestlers 0.0%) [142]. Only one study [155] in tier-2 wrestling reported no difference in upper limb injuries between males and females, specifically at the shoulder. Data specifically for shoulder injuries from 11 studies were suitable for the meta-analysis but showed considerable heterogeneity (I^2=80%) across studies (Supplementary Figure S2).

3.7.3 Trunk

Six moderate quality studies reported a higher incidence of trunk injuries in females. There were three studies in senior athletes including; rib stress injuries in Olympic level tier-5 rowers [49] (females 11.94% vs male 6.98%; p<0.05), all trunk injuries in tier-4 tennis (most common injury in female players 41%) [33], and back (female 13.1%, male 10.2%; p<0.001%) and pelvis (female 4.2%, male 2.9%; p=0.009) injuries in tier-2 snowboarding [160]. There were three studies in adolescent athletes including; multiple different tier-3 sports (spine female 11.3%, male 8.2%) spine female 11.3% male 7.7%; p<0.013) [71] and specifically in tier-2 ice hockey (spine injuries male 9.2%, female 26.9%; female spine OR 3.66 [95% CI, 1.30-10.32])[69]. Eight moderate quality studies reported a higher incidence of trunk injuries in male athletes in Australian Rules football [81], lacrosse [96, 136], weightlifting [125], waterpolo [127, 152], swimming [106], tennis [53] and track running [70]. Male athletes were between 1.73 (95% CI, 1.17-2.54; basketball) [96] and 4.31 (95% CI 2.07-8.96; lacrosse) [96] increased risk of trunk related injuries. Four moderate quality studies reported no significant sex difference in the rate or proportion of trunk injuries in Crossfit [83], ice hockey [113], swimming and diving [50] and skiing [55]. No meta-analysis was conducted due to the lack of sufficient data reporting similar types of trunk injuries.

3.7.4 Concussion

Female athletes were reported to be at 1.3 (95% CI 1.03-1.8) (basketball) [120] to 8.46 (95% CI 1.04-68.77) (football) [66] times greater risk of concussion than male athletes in the same sports. Moderate quality evidence across twenty studies [42, 58, 61, 66, 69, 72, 81, 84, 88, 95, 98, 105, 107, 112, 119, 120, 154, 184, 196] showed a significantly higher incidence of sports related concussion in female athletes in sex comparable team sports. Four studies [88, 95, 112, 184] more specifically showed that the highest IIR were consistently seen in competition, with the highest rates reported in football (female 19.38 vs male 9.69/10,000 AE's) [112] (female 1.10 vs male 0.69/1000 AEs) [154] and judo (female 1.92 vs 1.18/1000 AE) [154]. Six studies [61, 66, 120, 159, 175, 197] reported injury proportion ratios, in female athletes sports related concussion accounted for a greater proportion of total injuries than in male athletes. IPR ranged from 1.4 [120] to 2.5 [120, 159, 175]. One study [136] in lacrosse reported a higher incidence of concussion in male athletes (0.29/1,000 AE's vs 0.10 in females; RR 2.99, 95% CI 1.65-5.79). One study [155] in wrestling reported a higher incidence of head/neck injuries in male athletes and one study [113] in ice hockey reported a higher incidence of head/neck injuries in female athletes but neither study specifically reported on concussion. Two studies [153, 162] reported no sex difference in the rate of concussion in football [153] (tier-2) and basketball [162] (tier-2 adolescent). The highest volume of studies for sports related concussion were from tier-3 athletes. The meta-analysis of 14 studies for sport related concussion showed an overall significant RR of 1.84 [1.76-1.92] for females (Figure 5).

3.7.5 Fractures

Stress fractures

There was moderate quality evidence that female athletes have 1.75 [115] to 3.37 [166] times greater risk of bony stress injury than male athletes. Five studies [25, 104, 115, 124, 166] including team and individual sports from adolescent and senior athletes (tier-3) consistently reported a higher rate and incidence of bony stress injury in female athletes. Overall, incidence ranged from 2.2/100,000 AE [115] to 9.13/100,000 AE [104]. In specific sports the highest reported IIR was in cross-country running (female IIR 28.59/100,000 AEs vs male IIR 16.14/ 100,000 AEs) [104]. The meta-analysis of four studies for stress fractures injuries showed an overall significant RR of 2.03 [1.77-2.34] for females (Figure 6).

Acute fracture

Conversely to stress fractures, moderate quality evidence in 15 studies [32, 65, 67, 70, 117, 131, 155-157, 160, 163, 166, 172, 188, 197] highlighted a significantly higher rate of acute fracture in male athletes across multiple different sports. Three studies [155, 172, 197] reported that acute fracture accounted for a significantly greater proportion of total injuries in male athletes in football (IPR 1.9, 95% CI 1.11-3.26) [172], basketball (IPR 2.49 [95% CI 1.59-3.91] [172, 197], lacrosse (IPR 21.3% vs. 10.8%; p < 0.01) [157] and wrestling (male 15.7% [CI 14.-16.7], female 10.6% [95% CI 7.5-13.7]) [155]. Male athletes were 1.8 (RR 1.8, 95% CI 1.37-2.7) [166] to 2.8 (RR 2.8, 95% CI 2.45-3.24) [131] times more likely to sustain acute fracture than female athletes with the highest risk in competition. Male athletes had an OR of 1.21 (95% CI 1.14-1.27) [163] for acute fracture across all recreational sports. Acute fracture data were from studies in all tiers of the participant classification framework. The meta-analysis of five studies for acute fractures injuries showed an overall significant RR (1.43 [1.23-1.67] for males (Figure 7).

3.7.6 Overuse injuries

Sixteen moderate quality studies [28, 53-55, 62, 71, 80, 91, 108, 115, 124, 127, 151, 171, 187, 188] reflected a greater burden of overuse injury in female in athletes. Nine of these studies were in adolescent athletes [71, 80, 115, 123, 124, 127, 139, 150, 188]. Reported injury rates were IR 24.0/100 athletes (95% CI 20.7-27.3) (males IR 10.5 [95% CI 7.4-13.7]) in skiers [55] and 16.8/10,000 AE (males 14.9; p<0.0001) across multiple sex comparable sports [171]. The proportion of overuse injuries in females compared to males varied by study; female overuse IPR 1.32 (95% CI 1.14-1.52)[124], female 18% vs male 4% [53], female 53.1% vs male 47.5% [54] female 18% vs male 11% (p<0.006)[28], female 13.3% vs 5.5% male[127], female 62.5% male 41.9% [71, 188], lower leg – male 24.9%, female 31.7%, medial tibial stress syndrome – male 10.1% vs female 18.0% [151]. One study in tier-3 adolescent athletes that had specialised in a single sport reported that females were 1.50 [95% CI, 1.14-1.99]; p<0.004) times more likely than males to sustain an overuse injury [80]. These studies included tennis [53], skiing [55], sex comparable senior sports [54, 171], water polo [127] adolescent athletes that have specialised in a single sport [80] and high school sports [151]. One study highlighted that the ratio of acute to overuse injury was higher among male athletes (RR 3.67 [95% CI 3.02-4.46]) than female athletes (RR 1.53 [95% CI 1.28-1.83]) [171]. One tier-4 study[167] in football reported a higher rate of overuse injury in male players (male 4.19/1000 player hours, female 2.84 p<0.01; RR 1.48 [95% CI, 1.12 1.95]). Three moderate quality studies in adolescent athletes in swimming[139], cross country [150] and skiing [123] and one study in senior athletes across multiple sports [142] reported no significant sex difference for overuse injuries. These studies were all in tier-3 athletes. No meta-analysis was conducted due to the lack of sufficient data by body location for overuse injuries.

4 Discussion

The focus of this review was to identify where differences in injury are most apparent between the sexes in sport. There was evidence to support sex specific injury profiles. Injury is rarely the result of one single factor, rather the interaction of multiple factors. Recent studies [198-201] have highlighted that biological sex interacts with gender, social and environmental factors, all of which play a role in how athletes are injured and must be considered in the overall web of determinants.

4.1 Lower extremity injuries

On balance there was higher volume of moderate quality evidence that female athletes were more susceptible to lower limb injuries overall than there was for male athletes, which was consistent with recent reviews [202-204] that highlighted the lower limb injury burden in female athletes. More specifically in this review, the higher rate of knee and foot/ankle injuries was consistent with other studies [205]. Changes that occur at the onset of puberty may influence this injury profile in female athletes. Males experience an increase in strength, neuromuscular performance, and power within one year of peak velocity of growth in height and weight not typically seen in females[206]. If left unaddressed, this strength deficit and altered biomechanics may leave female athletes more vulnerable to lower limb injury both during the adolescent period and in the longer term.

Male athletes appear to have a significantly greater propensity for hamstring injury than female athletes by as much as 62-64% [28, 89, 90], with high rates of reoccurrence, particularly in sports and playing positions with explosive physical demands. This was consistent with Zech et al. [207] who reported a higher incidence of thigh injuries in male athletes. An increasing incidence of hamstring injuries has also been observed in elite male football players[208], and there is evidence [209] that male athletes are generally more susceptible to muscular injury than female athletes. There is a growing body of research investigating mechanisms of [210] and risk factors for hamstring injury [211, 212] and although male sex is not cited as a risk factor the data predominantly comes from male cohorts. The injury mechanism typically associated with hamstring injury involves eccentric overloading and/or overstretching with a combination of hip flexion and knee extension[213]. Consistent with other studies [207, 214, 215], data in this review showed that male athletes were more susceptible to hip/groin injuries. There is evidence of sex differences in groin anatomy and pelvic and hip joint morphology that may contribute to the higher incidence of hip/groin injuries in male athletes[216]. Subtle differences in attachment sites of adductor and abdominal musculature alter the line of muscle action in certain positions and possibly making the tendons more vulnerable to higher tensile forces in male athletes[217]. When playing sports in positions that require a combination of kicking and a rapid change of direction, the male adductor complex may be put into an ‘at injury risk’ position.

Neuromuscular training programmes with the inclusion of specific components targeting adductor [218] and hamstring [219, 220] muscles have been effective in protecting against these types of injuries [221, 222], particularly to the knee in high demand pivoting sports that require rapid change of direction. In female athletes these programmes are more effective when implemented during adolescence [221-224]. Adolescence could therefore be a window of injury prevention opportunity in female athletes. Given the volume of evidence supporting targeted neuromuscular training programmes in reducing the risk of injuries that affect both male and female athletes, these programmes should be an integral part of all coach and player education and training behaviour. Organisations that influence the provision of sport from financial support to technical development should prioritise neuromuscular training programmes.

4.2 Upper extremity injuries

There was a higher volume of moderate quality evidence reporting that male athletes across all levels of the participation pyramid had a greater risk of upper limb injuries than female athletes in both team and individual sports, particularly shoulder injuries. The greatest risk was seen in judo, ice hockey and water polo, all considered contact collision sports [225] with some demand on the upper limb and shoulder. Those studies that did report female athletes with a higher incidence of upper limb injury were lower contact/individual sports that may be categorised as ‘reverse chain’ or ‘above shoulder height with or without throwing’ in terms of playing demands on the shoulder [225]. These sports typically include repetitive upper limb movement patterns and may therefore be more likely to result in overuse injuries, which would be consistent with the findings is this review relating specifically to a higher rate of overuse type injuries in female athletes. The Bern consensus statement [225] for shoulder injury prevention in sport provides best practice guidance on risk factors and considerations for primary and secondary prevention of shoulder injuries in all sport.

4.3 Trunk injuries

On balance, the incidence of injuries to the trunk in male and female athletes could be considered equivocal from the data in this review. Studies that showed a higher incidence in male athletes were from sports that primarily load the lower limb. Studies that showed a higher incidence in female athletes were more balanced across sports that primarily load the upper limb or the lower limb. Previous research has shown a bi-directional relationship between lower limb [226, 227] and upper limb [228] characteristics/injury and trunk related pain, injury, mobility or deficit. Dynamic activities that occur during sport and involve any acceleration/deceleration movement of the limbs require a stable base in the lumbo-pelvic region to absorb and transfer load [229]. It is widely accepted that lumbo-pelvic stability is created by appropriate dynamic neuromuscular control of the trunk musculature. Studies have demonstrated an association between deficiencies in trunk muscles and incidence of lower limb injuries [230-232]. Studies investigating sex differences specifically in the fatiguability of anterior and lateral trunk muscles have reported inconsistent results [232-234]. Regardless, the findings in this current review further highlighted the importance of neuromuscular training programmes which include core strength and balance exercises for both male and female athletes.

4.4 Sports related concussion

The higher incidence of sports related concussion in females [207, 235, 236] is not well understood. A number of contributing factors have been cited but not thoroughly investigated, such as more honest reporting in females [207, 237-239], inadequate neck strength [240, 241], structural differences in the brain [242] and hormonal profile [235, 243-246]. The limited volume of research investigating concussive injury mechanisms in female sports has contributed to a lack of evidence informed preventative strategies and physical preparation protocols. Studies identified using our search terms consistently reported that female athletes have greater symptom severity and take longer to recover from sport related concussion [42, 95, 120, 133, 196, 247]. This highlighted a potential need for specific guidelines for rehabilitation and return-to-play for female athletes to optimise recovery from concussion. Further, a recent review [248] showed that there is a considerable under-representation of female participants (19.9%) in the studies that inform the recommendations of the most influential concussion consensus and position statements and that 40.4% of the studies include no female participants at all. There is likely a complex interaction between intrinsic biological sex with extrinsic, sociocultural or gendered behavioural differences. This is currently a poorly understood area and research is needed to advance knowledge and inform prevention and rehabilitation protocols.

4.5 Fractures

Female athletes were at increased risk of bone stress injuries across multiple sports, a finding consistent with a review examining sex differences in running related injuries [249]. This sex difference may be underpinned by the interaction between energy availability, the menstrual cycle and bone health; the female athlete triad [250], as described within the relative energy deficiency in sport (RED-S) model [251]. Adolescence is widely accepted as a critical period for achieving peak bone mass [252] and an increasing body of evidence [251, 253, 254] supports the critical role of nutrition and energy availability in developing and maintaining bone health. Education to reinforce the importance of, and strategies for, achieving optimal bone strength during adolescent years is a key preventative strategy. Strength training has been shown to promote the development of bone strength [252, 255] in adolescent female athletes and in older cohorts [256-258].

4.6 Overuse injuries

There was moderate quality evidence in this review of a higher incidence of overuse injuries in female athletes, particularly in adolescent athletes. One study [80] reported that after controlling for all variables, athletes categorized as highly specialized in one sport had 1.46 (95% CI, 1.04-2.04) times greater odds of an overuse injury than low specialized athletes (p=0.03).

Overuse injuries result from acute micro trauma and repetitive stress and tend to occur when inadequate time is provided for the body to recover from and adapt to the stress. Previously identified factors associated with overuse injury include under recovery, excessive loading and under preparedness (or underloading of the musculoskeletal system) [259]. These factors can compromise an athlete's ability to tolerate and adapt to the training load. Athletes who are exposed to sports with repetitive movement patterns either due to the nature of the sport or the high training volume in a single sport may be at increased risk of overuse injury due to repeated loading of the same structures. Although risk factors associated with overuse injury could be present in both male and female athletes, the previously highlighted sexually divergent changes that occur during adolescence could make females more susceptible to overuse injury if not considered in the overall balance of sports participation e.g., strength development to tolerate training loads.

The menstrual cycle is an essential marker of overall health in female athletes; phase of the menstrual cycle has been cited as a possible risk factor for ACL injury due to the influence of circulating estrogen on joint laxity and neuromuscular control [260]. A limited number of studies have investigated the overall risk of injury across the menstrual cycle [261, 262] with inconclusive results. Loss of the menstrual cycle (amenorrhea) has been shown to put female athletes at increased risk of injury, particularly bone stress injury [251].

4.7 Limitations and future research

Although quality assessment was undertaken using the Downs and Black checklist, a detailed domain based RoB assessment was not carried out on the studies included in this review. Non-randomised study designs are typically at increased susceptibility to bias and preliminary analysis using the ROBINS-E tool confirmed that studies in this review were likely at "high risk of bias". This is an important consideration when interpreting the findings of the review.

In assigning data to the different tiers across the participant classification framework, where studies did not explicitly state the level of participation, tier classification was assumed based on the data presented. There was substantial heterogeneity across the studies included in some of the meta-analyses, somewhat limiting the generalisability of the results. The findings of this review should therefore be considered carefully.

Studies in this review did not consistently include training histories and protocols so it was unclear whether these injury patterns exist in the presence or absence of injury prevention strategies. Future sports injury epidemiological research should include sex analysis and include more factors outlined in the IOC consensus statement [263] to improve consistency of injury data collection. Given the lack of clarity on the impact of female physiology on injury, reproductive status and menstrual cycle phase should also be included as standard in injury and illness data collection as outlined in the 'Female Athlete Health Domains' supplement to the IOC consensus statement [264]. It should also be noted that there was inconsistent use of 'sex' (biology) and 'gender' (social construct) within the literature, studies within this review did not report how participant sex and/or gender information were obtained, and it was assumed that athletes included in the studies of this review were unlikely to have under-gone sex verification. Therefore, the results may represent a combination of differences due to biological sex and gender.

Areas for future research include surveillance and analysis of injury mechanisms across female sport and investigations into the underlying mechanisms in female athletes' susceptibility to sports related concussion and prolonged recovery. Increased inclusion of female research participants and female-only studies with appropriate methodological design will enable sports training and injury prevention recommendations and strategies to be based on relevant research.

5 Conclusions

There were clear sex-specific body location injury patterns in sports across the participation pyramid; the meta-analyses showed that female athletes had a higher risk of knee and foot/ankle injuries, sports related concussion and bone stress injuries. Male athletes were at higher risk for hamstring, injuries and acute fractures than female athletes. Data showed that overall injury rates were generally higher in male athletes across the participation pyramid, or that there was no significant sex difference. Strength and neuromuscular training programmes may be effective for both male and female athletes for prevention of musculoskeletal injuries, particularly to the lower limb, however it is important to be aware of sex specific injury patterns and tailor approaches accordingly. Sex is only one factor that will determine injury risk, therefore must be considered in combination with other individual risk factors and with the demands of each sport. Further research is needed to develop sex specific prevention and return to sport protocols for sports related concussion.

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Declarations

Contributors' Statement

According to the definition given by the International Committee of Medical Journal Editors (ICMJE), the authors listed qualify for authorship based on making one or more of the substantial contributions to the intellectual content of the manuscript. Grant funding application [Hume]; Study conception and design [Hume, Hardaker, Sims]; Acquisition of data [Hardaker], Extraction of data [Hardaker]; Interpretation of data [Hardaker, Hume, Sims]; Drafting of manuscript [Hume, Hardaker, Sims]; Critical revision of manuscript [Hardaker, Hume, Sims]. All authors read and approved the final version.

Authors' Conflicts of Interest

Financial interests: Natalie Hardaker was employed by ACC prior to and throughout the duration of the project. ACC provided funding for the project. The opinions expressed are those solely of the authors and do not necessarily reflect those of the Accident Compensation Corporation, New Zealand. Patria A Hume and Stacy Sims declare that they have no financial interests.
Non-financial interests: The authors declare that they have no non-financial interests.

Compliance With Ethical Standards

No ethics approval was gained given it was a literature review.

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Provenance And Peer Review

Not commissioned, externally peer reviewed.

Data Availability

All data are included in the supplementary tables.

Tables

Table 1 Study inclusion and exclusion criteria.

Population	Inclusion: Healthy active participants, all levels of sport, up to 65 yrs.
	Exclusion: General population – i.e., not sport or activity related injuries reported, over 65 yrs.
Intervention	Inclusion: Standardized injury data collection intervention.
	Exclusion: Self report measure, not medically diagnosed injury.
Comparisons	Inclusion: Analysed and/or reported by sex.
	Exclusion: No sex analysis.
Outcomes	Inclusion: Injury rate, injury incidence, injury rate ratio, odds ratio, injury proportion ratios, reported by sex.
	Exclusion: Illness clearly from aetiology other than transfer of kinetic energy (as per definition in IOC consensus statement).
Study design	Inclusion: Longitudinal cohort studies, prospective and retrospective cohort studies, cross sectional, descriptive epidemiology.
	Exclusion: Systematic or narrative reviews, case reports and case series, commentaries and opinion pieces.
Other limiters	Inclusion: Full publications in the English language.
	Exclusion: Unavailable in English or in full text format, did not provide additional information for any of the identified sections and subsections of this review.

Table 2 Studies that showed significant, or not, sex differences for acute and overuse combined injury rates for Tier 1-5 participants.

Tier	Significant sex difference	No significant sex difference	Not reported on
Tier-5: 8 studies	Team sports: 1 study [32] male athletes higher IIR. 1 study [49] female athletes higher IIR.	Team sports: 0 studies.	2 studies [50, 51].
	Individual sports: 0 studies male athletes higher IIR. 1 study [27] female athletes higher IIR.	Individual sports: 3 studies [26, 52, 76].	
Tier-4: 40 studies	Team sports studies: 5 studies [28, 79, 102, 167, 169] male athletes higher IIR. 1 study [170] female athletes higher IIR.	Team sports studies: 6 studies [30, 40, 58, 113, 137, 166].	6 studies: [31, 48, 135, 138, 168, 171].
	Individual sports: 9 studies [21, 24, 25, 33, 36-38, 53, 55] male athlete higher IIR. 5 studies [54, 56, 75, 78, 134] female athletes higher IIR.	Individual sports: 8 studies [20, 22, 23, 29, 57, 77, 110, 111].	
Tier-3: 98 studies (*3 studies in 2 categories)	Team sports: 9 studies [66, 87, 89, 90, 96, 116, 136, 180]*[143] male athletes higher IIR. 8 studies [47, 67, 92, 140, 148, 151, 172, 197] female athletes higher IIR.	Team sports: 10 studies [45, 61, 73, 105, 133, 142, 149, 152] [93]* [106]*.	51 studies: [20, 34, 35, 42, 64, 71, 80, 88, 91, 94, 95, 97-99, 101, 103, 104, 107-109, 112, 115, 118-122, 127-132, 141, 144, 146, 147, 173, 175-179, 182-185, 187-189, 196].
	Individual sports: 4 studies: [34, 35, 265] [96]* male athletes higher IIR. 7 studies [41, 114, 124, 139, 145, 181, 186] female athletes higher IIR.	Individual sports: 12 studies [44, 46, 59, 60, 74, 100, 123, 150, 174, 266] [93]* [106]*.	

Tier-2: 30 studies (*2 studies in 2 categories)		Team sports: 7 studies [39, 62, 63, 153, 162] [154]* [190]*.	18 studies [43, 65, 68, 69, 72, 81-83, 86, 126, 155-157, 159, 160, 191-193].
	Individual sports: 1 study [161] female athletes higher IIR.	Individual sports: 6 studies [70, 125, 154, 158, 194]*[190]*.	
Tier-1: 5 studies	Team sports: 3 studies [84]*[163]*[164]* male athletes higher IIR. 0 studies female athletes higher IIR.	Team sports: 0 studies.	2 studies [85, 165].
	Individual sports: 3 studies [84]*[163]*[164]* male athletes higher IIR. 0 studies female athletes higher IIR.	Individual sports: 0 studies.	

*study includes data from both team and individual sports combined

Table 3 Studies that showed significant, or not, sex differences by injury location for Tier 1-5 participants.

Tier	Lower extremity	Upper extremity	Trunk	Head/Neck/Concussion
Tier-5	ADULTS: Willauschus, 2021 [52]; Engebretsen, 2010 [27]; Edouard, 2018 [26]	Trease, 2020 [51]; Engebretsen, 2010 [27]	Harris, 2020 [49]; Kim, 2020 [50]	Engebretsen, 2010 [27]; Junge, 2006 [32]
Tier-4	ADULTS: Abadi, 2021 [53]; Kim, 2021 [56]; Mattiussi, 2021 [57]; Edouard, 2014 [24]; Edouard 2015 [25]; Edouard, 2016 [38]; Gescheit, 2017 [75]; Hagglund, 2009 [28]; Hunt, 2017 [137]; Johansen, 2015 [134]; Larruskain, 2018 [167]; Moreno-Perez, 2019 [33]; Toohey, 2019 [79]; Traneus, 2016 [170]; Westermann [110]	Abadi, 2021 [53]; Chimera, 2022 [54]; Gescheit, 2017 [75]; Johansen, 2015 [134]; Traneus, 2016 [170]; Westermann, 2015 [110]	Abadi, 2021 [53]; Fröhlich, 2021 [55]; Moreno-Perez, 2019 [33]	Mertz, 2022 [138]; Vedung, 2020 [58]; Hill, 2019 [31]; Toohey, 2019 [79]

Tier-3	ADULTS: Chan, 2021 [141]; Comeau, 2023 [142]; Cross, 2010 [89]; Cross, 2013 [90]; Dalton, 2015 [91]; Eckard, 2017 [92]; Eckard, 2017 [93]; Fares, 2019 [74]; Fraser, 2021 [145]; Fulstone, 2016 [94]; Harmer, 2008 [174]; Kerbel, 2018 [99]Kerr, 2016 [20]; Lievers, 2020 [149]; Mauntel, 2017 [101]; Post, 2022 [151]; Roos, 2017 [105]; Sallis, 2000 [267]; Trojan, 2019 [108]; Tummala, 2018 [109]; Beynnon, 2005 [64]; Opar, 2014 [35]; Vaandering, 2022 [61]; Rizzone, 2017 [104]; Trojan, 2019 [108, 151]	Comeau, 2023 [142]; Deckey, 2020 [144]; Fares, 2019 [74]; Hibberd, 2016 [97]; Kerr, 2015 [100]; Lanzi, 2017 [179]; Melvin, 2018 [102]; Owens, 2009 [103]; Sallis, 2000 [267]; Schroeder, 2022 [152]	Hassebrock, 2019 [96]; Sallis, 2000 [267]; Schroeder, 2022 [152]	Covassin, 2003 [88]; Covassin, 2016 [42]; Deckey, 2020 [95]; Gessel, 2007 [95]; Hurtubise, 2015 [98]; Roos, 2017 [105]; Schroeder, 2022 [152]; Simmons, 2017 [107]; Zuckerman, 2015 [112]; Zupon, 2018 [113]; Vaandering, 2022 [61]; Zupon, 2018 [113]

	ADOLESCENTS: Belilos, 2023 [139]; Borowski, 2008 [197]; Cierna, 2017 [41]; Collins, 2008 [116]; Darrow, 2009 [172]; Fernandez, 2007 [173]; Hinton, 2005 [136]; Kerr, 2011 [175]; Kerr, 2018 [177]; Kolstrup, 2016 [67]; Marshall, 2020 [150]; Messina, 1999 [180]; Mitchell, 2015 [122, 182]; Nelson, 2007 [183]; O'Connor, 2020 [60]; Pierpoint, 2016 [124]; Powell, 2000 [47]; Rauh, 2000 [186]; Stracciolini, 2014 [188]; Stracciolini, 2015 [71]; Swenson, 2013 [129]; Swenson, 2013 [128]; Yard, 2008 [133]	Belilos, 2023 [139]; Collins, 2008 [116]; Hinton, 2005 [136]; Kerr, 2011 [176]; Kerr, 2018 [177]; Maciejewski, 2016 [44]; O' Connor, 2020 [60]; Pytiak, 2018 [185]; Stracciolini, 2014 [188]; Stracciolini, 2015 [71]	Cierna, 2017 [41]; Hinton, 2005 [136]; Kerr, 2018 [177]; Stracciolini, 2014 [188]; Stracciolini, 2015 [71]	Belilos, 2023 [139]; Borowski, 2008 [197]; Bretzin, 2021 [140]; Bretzin 2018 [196]; Cierna, 2017 [41]; Collins, 2008 [116]; Hinton, 2005 [136]; Huffman, 2008 [118]; Kerr, 2011 [175]; Kerr, 2017 [66]; Kerr, 2018 [177]; Lincoln, 2011 [119]; Marar, 2012 [120]; O' Connor, 2017 [184]; Tirabassi, 2016 [189]; Yard, 2008 [133]
Tier-2	ADULTS: Gill, 2021 [81]; Hollander, 2021 [82]; Mintz, 2021 [158]; Sugimoto, 2020 [83]	Gill, 2021 [81]; Mintz, 2021 [158]; Sugimoto, 2020 [83]; Rugg, 2021 [160]	Gill, 2021 [81]; Rugg, 2021 [160]	Gill, 2021 [81]; Morrissey, 2020 [159]
	ADOLESCENTS: Hosea, 2000 [43]; Honrado, 2021 [156]; Khodee, 2020 [157]; Owoeye, 2020 [62]; Leppanen, 2017 [192]; Pasanen, 2018 [68]; Quatman, 2009 [125]; Reid, 2012 [70]; Sokka, 2020 [63]; Willick, 2021 [161]; Zynda, 2022 [162]	Khodaee, 2020 [157]; Quatman, 2009 [125]; Reid, 2021 [70]; Robinson, 2014 [193]; Sokka, 2020 [63]; Forward, 2014 [65]; Hoge, 2020 [155]	Sugimoto, 2020 [83]; Polites, 2014 [69]; Quatman, 2009 [125]; Reid, 2012 [70]	Chatha, 2020 [153]; Chun, 2021 [154]; Delaney, 2014 [191]; Khodaee, 2020 [157]; Polites, 2014 [69]; Schallmo, 2017 [126]; Tsushima, 2019 [72]; Zynda, 2022 [162]; Hoge, 2020 [155]
Tier-1	ADULTS: Aman, 2019 [85]	Stogner, 2020 [164]		Aman, 2019 [85]; Xiao, 2022 [165]

Table 4 Participant characteristics and main findings for the Tier-5 athlete studies.

Reference & Quality score	Focus	Participants characteristics, age (mean±SD)	Findings/Comment
Willauschus 2021 [52]; 18, 64% Moderate	Foot & ankle injuries in taekwondo.	107 athletes (47% female) from a national Olympic taekwondo training centre were investigated prospectively for training & competition injuries over 5 yrs (January 1, 2014–December 31, 2019). Age 19.3±3.2 (15-27), male 20.9±3.4 (15-26), female 19.5±3.0 (15-27). yrs of experience 9.6±3.3 (6-20), male 10.3±3.8 (6-20), female 9.1±3.5 (6-20).	Overall IIR ankle joint 13.14/1000h (95%CI 1.5-25.9). No sig. sex diff.; male 14.8 (95%CI 2.7-17.9), female 12.7 (95%CI 3.6-21.1). For the foot 4.9 (95%CI 2.0-7.9). No sig. sex diff. male 5.3 (95%CI 2.0-7.8), female 3.9 (95%CI 2.6-7.0). The IIR during competition was higher overall for both ankle joint (training 2.9 [95%CI 2.0-3.7] competition 20.9 [95%CI 15.4-26.5] p<0.01)and foot injuries (training 2.7 [95%CI 2.0-7.9] competition 6.8 [95%CI 5.4-8.2]; p<0.01). This pattern was evident in males & females.
Harris 2020 [49]; 16, 57% Moderate	Rib stress injuries in 2012–2016 (Rio) Olympiad.	151 Australian rowing team athletes for 88773 athlete days. 85 qualified athletes (2013-15) plus 66 'shadow squad' athletes seeking qualification in 2016.	Overall IIR 0.2714/1000 athlete days (2013-15), shadow squad (2016) 0.1344/1000 athlete days. Rib injury prevalence 9.15%, (4%-15.4% over 2013-2015). Shadow squad prevalence 4.27%. Prevalence highest among lightweight athletes 13.04% in first 3 yrs of Olympiad. Overall 4- year period prevalence for at least one rib stress injury 9.9% (incl. all 151 athletes monitored from 2013 to 2016) with 2.7% having more than one (n=4). Sex diff. in prevalence (p=0.05). Prevalence highest in females 11.94%, lightweight (13.04%) & sweep (11.49%) athletes in 2013–2015 Australian rowing team & in females (8.51%), lightweight (5.88%) & scull (8.11%) athletes in 2016 shadow squad.
Kim 2020 [50]; 20, 71% Moderate	Acute & overuse injuries in aquatic sports.	241 athletes, trained average of 4.5 hrs/day, 5 days/wk. For 1 yr, athletes were present at training centre for 9.5 months (41.25 wks). Swimmers & divers trained 4 hrs/day, 5 days/wk, for 9 months (39 wks); water polo players & artistic swimmers trained 5 hrs/day, 5 days/wk, for 10 months (43.5 wks). Swimming; 30 males 24.4±4.4 yrs, 1.84±0.03 cm, weight (kg) 78.9 (5.6), BMI 23.3 (1.0), 31 females 23.7±2.6 yrs, 1.71±0.02 cm, 63.4±1.3 kg, BMI 21.6±0.6. Diving; 32 males 23.6±0.4 yrs, 1.67±0.05 cm, 62.0±4.1 kg, BMI 22.3±0.2, 24 females 22.8±1.7 yrs, 1.56±0.04 cm, 52.3±0.9 kg, BMI 21.4±1.1. Water Polo; 73 males 24.4±3.4 yrs, 1.82±0.05 cm, 86.5±9.2 kg, BMI 26.0±2.8. Artistic swimming; 51 females 19.1±1.9 yrs, 1.63±0.03 cm, 53.13±4.0 kg, BMI 19.83±1.1.	Overall IR 2.74 (95%CI 2.55–2.93)/1000 hrs of training. Swimming IR 4.60 (95%CI 4.04-5.17) (male 4.10, female 5.13 injuries/1000 hrs of training; RR = 1.25, [95%CI 0.34-4.57]). Diving IR 3.15 (95%CI 2.69-3.62), (male 2.61, female 3.72; RR = 1.43, [95%CI 0.29-6.92]). Overall IIR 13.41 (95%CI 12.48-14.34)/1000 AEs. Swimming IIR 19.37 (95%CI 16.99-21.75)/1000 AEs, (male 17.43, female 21.35/1000 AEs; RR 1.22 [95%CI 0.65-2.29]). Diving IIR 13.32 (95%CI 11.35-15.28)/1000 AEs, (male 11.18, female 15.51; RR 1.39 [95%CI 0.65-2.98]). Injury patterns by site & type - no sig. sex diff. (most notable diff. in diving, male = lower extremity, trunk & female = trunk, upper extremity).

Trease 2020 [51]; 18, 64% Moderate	Acute & overuse injuries in rowing.	153 athletes over London 2012 & Rio 2016 Olympic cycles (8 yrs). Demographic information available as supplementary information online.	No sig diff. in height or weight of athletes in any year studied. Overall IIR for 2 Olympic cycles 4.1–6.4 injuries/Athlete Days (AD's). Chest wall injuries female RR 1.4 (95%CI 1.2-1.7). Low back pain female RR 0.5 (95%CI 0.4-0.6). Forearm injury female RR 1.06 (95%CI 0.8-1.5). Knee injury female RR 1.10 (95%CI 0.8-1.6).
Edouard 2018 [26]; 19, 68% Moderate	Acute & overuse injuries in gymnastics.	Not included.	Overall IR 84.1±17.5/1000 registered gymnasts (54 female (66%, 27 male (33%)). No sig. sex diff. (female 86.4±22.0 vs male 79.9±28.9/1000 gymnasts). Time loss IR 32.2±11.1/1000 gymnasts. No sig. sex diff. (female 27.2±12.8 vs male 41.4±21.2/1000 gymnasts). Sig. sex diff. for ankle injuries; female 27.4±18.7 vs male 3.4±6.7/1000 gymnasts & training injuries; female 51.4±25.3 vs male 17.2±15.0/1000 gymnasts. Overall female IR RR=1.08; (95%CI 0.69 to 1.68). Female time-loss RR=0.66; (95%CI 0.33 to 1.32). Female ankle injury RR=7.95; (95%CI 1.00 to 63.1). Female training injury RR=2.98; (95%CI 1.10-8.09).
Engebretsen 2010 [27]; 17, 61% Moderate	Acute & overuse injuries in winter sports; skiing, snowboarding, skating, hockey, luge, bobsled.	2567 registered athletes (1045 females, 1522 males) No further detail reported.	Overall IR; 111.8 injuries/1000 registered athletes. Sig. (p=0.003) sex diff. in overall IR; female 131.1/1000 athletes, male athletes 93.3. Face, head & cervical spine (female 19.7%, male 21.4%) & knee (female 16.1%, male 10.7%) most prominent injury locations. followed for females by wrist (8.0%) & for male athletes by thigh (10.0%). Contusions (female 31.6%, male 25.5%, ligament sprains (female 19.8%, male 10.6%) & muscular strains (female 8.1%, male 16.3%) most common injury types. Female overall injury RR=1.4 (95%CI 1.1 to 1.8).
Junge 2006 [32]; 14, 50% Moderate	Acute & overuse injuries in football, handball, basketball, field hockey, baseball, softball, water polo, volleyball, beach volleyball.	Specifics not included.	Sex diff. overall IIR of time-loss injuries male 24.7/1000 player matches female 15.9 (p<0.05). Handball IR higher in female 145/1,000 player hrs, male 89/1,000 player hrs. sig. (p< 0.05) more injuries in male players than in female players were expected to result in time loss male 40/1,000player hrs, female 36/1,000 player hrs. No diff. in incidence of time-loss injuries was observed between male & female players. Sig. sex diff. (p<0.05) in injury proportions; concussions female 4% vs male, 0.5% sprains female 19% vs male 9%, fractures female 3% vs male 6% & lacerations female 5% vs male 11%. Football; type of injuries differed sig. (p<0.01), with fewer contusions & lacerations & more sprains & concussion in females. Basketball; location differed sig. (p<0.05), with twice as many head injuries (female 29%, Male 15%).

Kim 2015 [76]; 14, 50% Moderate	Acute & overuse injuries in judo.	24 male, 24 female athletes training at facilities.	Total IR 4.1 injuries/year for each athlete; 4.0 injuries/male athlete (4.5 for lightweights & 3.5 for heavyweights, 4.2 injuries/female athlete (4.5 for lightweights & 4.0 for heavyweights). Annual injury incidence 4.2 injuries/1000 h of training/athlete; male 4.1 injuries/1000 h of training (4.6 for lightweights vs. 3.6 heavyweights (z=4.7893, p<0.001)). Female 4.3 injuries /1000 h of training (4.6 for lightweights vs. 4.2 for heavyweights (z=1.9111, p>0.05)). Sig. sex diff. (p=0.0228) for grade III injuries. However, this was sig. only in a comparison between male heavyweights vs. female heavyweights (p=0.0041) NOT between male lightweights & female lightweights 42 (p=0.6347). Weight category female OR-1.04 (95%CI; 0.78 to 1.37, & the distribution of injury rate in the two categories was analogous to each other. Sex & weight diff. in IR not statistically sig. (p=0.8060).

OR: odds ratio; aOR: adjusted odds ratio; CI: confidence interval; HR: hazard ratio; IRR: incidence rate ratio; RR: relative risk; IQR: interquartile range.

Table 5 Participant characteristics and main findings for the Tier-4 athlete studies.

Reference & Quality score	Focus	Participants characteristics, age (mean±SD)	Findings/Comment
Abadia 2021 [53]; 19, 61% Moderate	MSK injuries in professional tennis players during tournament play.	161 tennis players (44%) female. Athlete rank; singles 742 (27–2668), doubles 595 (13–1886). Most players (63.4%) competed both in singles & doubles matches. Age(yrs) 22.0±4.1, Height (cm) 1.74±0.09, weight (kg) 68.6±10.4, playing experience (yrs) 15 (6–31). Data collected over 5 ITF tournaments in 2019.	Across all tournaments 1167.7 hrs of play caused 36 musculoskeletal injuries. Overall IIR 30.8 injuries/1000 player hrs (95%CI 28.2–33.5). Male IIR 35.7 injuries/1000 player hrs (95%CI 32.1–39.2), female IIR 23.6 injuries/1000 player hrs (95%CI 19.7–27.4), male RR 1.4 (95%CI 0.7-2.8; p=0.280). 15% female players sustained an injury, 22% males sustained an injury. Overall acute IIR 18.8 (95%CI 16.6–21.1), overuse IIR 2.6 (95%CI 1.7–3.5), recurrent IIR 9.4 (95%CI 7.7–11.1). 68% male injuries were acute, 4% overuse & 25% recurrent. 45% female injuries were acute, 18% overuse & 36% recurrent. 32% male injuries were to the upper limb, 48% to the trunk & 20% to the lower limb. 9% female injuries were to the upper limb, 18% to the trunk & 64% to the lower limb.
Chimera 2022 [54]; 16, 57% Moderate	MSK injury & illness during Canada Games competitions from 2009-2019.	Retrospective data analysis. 8710 male & 8391 female athletes. Summer games 10169 (5457 male; 4712 female), winter games 6932 (3253 male; 3679 female). 3160 injuries in male athletes, 3272 injuries in female athletes.	Male IIR 362.8/1,000 athletes, female IIR 389.9 (p=0.004). Shoulder injuries accounted for highest proportion of injuries in male (11.3%) & female (11.8%) athletes. Muscle strains accounted for the highest proportion of injury type in both male (36.4%) & female (37.8%) athletes. Acute injuries accounted for 54.3% injuries in male & 46.9% in female athletes. Chronic injuries accounted for 45.7% injuries in male & 53.1% in female athletes. Overall injury & illness incidences were sig. higher in Winter, cf. to Summer, Canada Games. No sig diff. in overall IIR in females competing in Winter cf. to Summer Games. In female athletes, highest IIR freestyle skiing. Female OR in softball 3.8 [95%CI 2.9-5.1], canoe-kayak 2.4 [95%CI 1.5-3.8], rowing 2.2 [95%CI 1.53.2], sailing 5.6 [95%CI 2.8-11.1], swimming 1.7 [95%CI 1.2-2.6], tennis 2.3 [95%CI 1.4-3.8], triathlon 3.8 [95%CI 2.0-7.1], fencing 22.0 [95%CI 6.7-71.9], alpine skiing 2.3 [95%CI 1.5-3.5], biathlon 3.1 [95%CI 1.8-5.2], judo 1.8 [95%CI 1.2-2.8], snowboarding 2.6 [95%CI 1.5-4.5].
Fröhlich 2021 [55]; 19, 68% Moderate	Acute & overuse injuries in elite competitive alpine skiers throughout an entire season (i.e. an off-season preparation period & competition period).	44 members of Swiss National Ski Team, 25 females & 19 males, competing at different international levels (i.e. WC, EC, FIS races). Overall sample 21.4±2.8 yrs, 172.3±8.7 cm, 72.9±10.7 kg, BMI 24.4±2.0 kg/m2. 25 females 21.0±2.7 yrs, 166.6±5.4 cm, 65.6±6.6 kg, 23.6±1.9 kg/m2. 19 males 21.8±3.0 yrs, 180.0±5.7 cm, 82.5±6.8 kg, 25.5±1.67 kg/m2. Male height, weight & BMI sig. [p<0.01], higher than females.	Across entire season; traumatic IR 120.5/100 athletes, overuse IR 63.6 & overall IR 184.1. Competition season; traumatic IR 77.3/100 athletes, overuse IR 18.2, & overall IR 95.5. Across entire season; traumatic injury female RR 1.031 (95%CI 0.630-1.690), overuse injury female RR 0.988 (95%CI 0.549-1.779), overall injury female RR 0.971 (95%CI 0.626-1.507). Sig. sex diff. for overuse injuries in competition season; female IR 24.0 (95%CI 20.7-27.3), male IR 10.5 (95%CI 7.4-13.7). No sex diff. for traumatic injuries (female 52.0 [95%CI 48.1-55.9], male 57.9 [95%CI 52.8-63.0]). Preparation period; traumatic IR 36.4 (95%CI 34.2-38.5), overuse IR 43.2 (95%CI 41.1-45.4), overall IR 70.5 (95%CI 68.4-72.5). Sig. sex diff. for traumatic injuries in preparation period; female 44.0 (95%CI 40.1-47.9), male 26.3 (95%CI 21.8-30.9). Sig. sex diff. for overuse injuries in the preparation period male 52.6 (95%CI 47.5-57.8), female 36.0 (95%CI 32.2-39.8). Type & body site of injury not reported by sex.

Kim 2021 [56]; 19, 68% Moderate	Acute & overuse injuries in adolescent judo. 10 months of data collection in 2019 prospective cohort study.	120 male athletes: 40 lightweight 18.82±2.31 yrs, 169.73±3.39 cm, 69.74±5.33, BMI 23.41±1.47, 40 middleweight 18.77±2.24 yrs, 177.48±4.21 cm, 85.11±6.45 kg, 25.11±1.68 kg/m2; 40 heavyweight 18.39±2.89 yrs, 181.24±6.86 cm, 108.82±12.49 kg, 33.98±4.95 kg/m2; 120 female athletes: 40 lightweight 18.13±2.90 yrs, 159.58±5.93 cm, 53.24±5.74 kg, 21.44±1.30 kg/m2; 40 middleweight 18.61±2.22 yrs, 166.19±3.55 cm, 67.45±4.57 kg, 23.94±1.99 kg/m2; 40 heavyweight 18.38±2.97 yrs, 172.09±4.32 cm, 90.11±11.87 kg, 31.33±6.63 kg/m2.	Overall IIR 12.60/1000 AEs, & the injury rate was lower in male athletes than in female athletes (female 15.66, male 9.49/1000 AEs; p<0.001). Sex diff. in IIR for all categories; Lightweight (male 10.24 [95%CI 8.15–12.71], female 16.71 [95%CI 14.02–19.77]), Middleweight (male 9.32 [95%CI 7.34–11.66]), female 15.46 [95%CI 12.91–18.37]), heavyweight (male 8.92 [95%CI 6.99–11.22], female 14.84 [95%CI 12.31–17.73]). Location of injuries was most frequent for lower extremity (39.71%), upper extremity (36.63%), trunk (16.69%), & head & neck (6.97%), female higher injury rate across all areas (p=0.023). Females higher rate of bone stress injury & tendinosis.
Mattiusi [57]; 19, 68% Moderate	Acute & overuse injuries in ballet. Prospective cohort study 2015-20.	123 elite professional dancers (66 female, 28.0±8.3 yrs; 57 male, 27.9±8.5 yrs across ranks of apprentice, artist, first artist, soloist, first soloist, principal & principal character artist. Dancers who joined or left company during study period were included for duration of their time in company.	283,453 individual dancer events (class: 99,733; rehearsal: 152,588; performance: 31,132). Scheduled dance events represented 417,693 hrs of individual dance exposure (class: 115,772; rehearsal: 209, 529; performance: 92, 392) over 5 seasons. Sig. main effect of company rank observed on medical attention injury incidence rate (p<0.001), medical attention IR lower in apprentices (2.5/1000 hrs 95%CI 1.9-3.2) than first soloists (4.5/1000 hrs; 95%CI 3.7-5.5; p=0.003) & principals (4.7/1000 hrs 95%CI 3.9-5.8; p=0.002). No sig. main effects of sex (p=0.031) or sex by rank (p=0.659) for medical attention IR or time loss IR (sex; p=0.496), sex by rank; p=0.205). Overall, injuries to distal lower extremity & joint/ligament tissue had greatest burden across all dancers. Ankle injuries (synovitis, impingement & bursitis) were greatest burden in female dancers. In male dancers, stress fractures to foot & lower leg had greatest burden. Nineteen of 21 stress fractures in male dancers were attributed to jumping & landing activities & 18 were non-traumatic.

Mertz 2022 [138]; 14, 50% Moderate	Maxillofacial injuries from NCAA Division I American Football, baseball, men's & women's basketball, men's & women's water polo, men's & women's tennis, men's & women's indoor volleyball, women's beach volleyball, women's lacrosse, & women's football.	Collegiate age (17-24 yrs) NCAA database 2015-19. No further demographic info included.	193 athletes across 13 sports sustained at least 1 maxillofacial injury over 4 athletic seasons. In males, American Football accounted for 26.4%, basketball 16.1% & water polo 14.0%. In females, basketball accounted for 9.8%, lacrosse 5.7%, & football 5.2%. Across all sports, male athletes experienced 70.5% maxillofacial injuries, while female athletes experienced 29.5% injuries. Overall incidence of maxillofacial injuries was 2.06/1000 AE hrs. Male IIR 1.92/1000AE, female 2.4/1000 AE hrs. Men's basketball (8.30 injuries/1000 AE hrs) & men's water polo (8.15 injuries/1000 AE hrs) highest IIR of all sports. Women's basketball highest IIR of women's sports (5.79 injuries/1000 AE hrs). Men's & women's tennis & baseball had lowest rates, all with fewer than 1/1000 AE hrs. Basketball male RR 1.43. Water polo male RR 3.79. Volleyball male RR 1.6.
Vedung 2020 [58]; 18, 64% Moderate	Concussion in football.	51 Swedish elite football teams. 959 players, 389 female 23±4.2 yrs, & 570 male 25±4.6 yrs.	Overall concussion game IIR 1.19/1000 hrs of game play, male 1.18, female 1.22 (NS). 1st league; concussion game IIR 1.27/1000 hrs of game play, male 1.33, female 1.23 (NS). Semi-pro; concussion game IIR 1.20/1000 hrs of game play, male 1.11, female 1.33 (NS). 83% concussions occurred during games. Two players sustained two concussions, & 36 concussions were distributed on 34 players. To compare the SRC IIR between male & female on the same level of play; female 1st league cf. to male 2nd league (females 0.8/1000 hrs of game play; males 0.9/1000 hrs of game play; p=0.79).
Allen 2012 [21]; 20, 71% Moderate	Acute & overuse injuries in professional ballet.	52. 27 female; 25±6 yrs, 162.2±3.7 cm, 49.2±4.0 kg & BMI 18.9±1.6 kg/m2. 27 male; 23±5 yrs, 179.6±4.3 cm, 71.7±4.7 kg & 22.2±1.4 kg/m2.	Overall IR 6.8 injuries/dancer (females, 6.3; males, 7.3; p>0.05). Severity of injury higher (p<0.05) in male dancers (9 days) than in female dancers (4 days). No sig. sex diff. for injury incidence due to extrinsic factors; females 1.49/1000 hrs, male 1.64/1000 hrs greater injury incidence related to intrinsic factors for males (3.12/1000 hrs) cf. to females (2.65/1000 h). Female had sig. (p<0.05) higher incidence of first-episode injuries (49%) than males & reported fewer recurrences (40%) & exacerbations (11%) (p<0.05). No correlation between age & incidence (r=-0.20, p=0.16) & age & number of injuries (r=-0.19, p=0.18).
Augusticova 2019 [22]; 16, 57% Moderate	Acute & overuse injuries in karate.	5 weight divisions per sex (<60 kg, <67 kg, <75 kg, <84 kg, & >84 kg for male athletes & <50 kg, <55 kg, <61 kg, <68 kg, & >68 kg for female athletes). All female bouts are scheduled for 2 minutes, all male bouts are scheduled for 3 minutes (real time).	Sig. sex diff. for IIRAE female 2.46, male 6.98. No sig. sex diff. for IIRME female 1.23, male 2.33. (Overall IIRAE & IIRME were 5.13 (95%CI, 3.82-6.74) & 1.98 (95%CI, 1.47-2.60, respectively. Female IIRAE RR, 0.35 (95%CI, 0.17-0.70). Female IIRME RR, 0.53 (95%CI, 0.27-1.05).

Bere 2015 [40]; 16, 57% Moderate	Acute & overuse injuries in volleyball.	No demographic info included. Competitions for under-18, under-19, under-20, under-21 & under-23 age categories were classified as junior events.	Match IIR 10.7/1000 player hrs (95%CI 9.5 to 12.0); male 10.5 (95%CI 7.6-13.4, female 7.8 (95%CI 5.5-10.1). No sig. sex diff. Time-loss IIR during match play 3.8/ 1000 player hrs (95%CI 3.0 to 4.5); male 2.1 (95%CI 0.8-3.3, female 2.6 (95%CI 1.3-3.9). No sig. sex diff. Overall injury male RR: 1.09, (95%CI 0.86 to 1.38). Incidence of time-loss injuries during match play was 3.8/ 1000 player hrs (95%CI 3.0 to 4.5). Time loss male RR 1.04, (95%CI 0.70 to 1.55).
Cierna 2017 [41]; 17, 61% Moderate	Acute & overuse injuries in karate.	295 karate athletes (119 female, 176 male)	Overall IIRAE, 35.6 (95%CI, 22.8-53.0, & overall IIRME 10.9 (95%CI, 7.0-16.2). No sig. sex diff.: females had a slightly higher IIRME & IIRAE. Female RRME 1.33 (95%CI, 0.61-2.90). Female RRAE 1.19 (95%CI, 0.54-2.60). Overall injury proportion 8.1 (95%CI, 5.2-12.1)
Edouard 2014 [24]; 18, 64% Moderate	Acute & overuse injuries in athletics.	Not included.	Sig. (p=0.001) sex difference in overall IR; Male 122.0±23.6, female 69.5±15.9/1000 registered athletes. Sig. (p=0.03) sex difference in time-loss IR; Male 56.9±16.5, female 31.5±9.4/1000 registered athletes. Male overall injury RR=1.8 (95%CI, 1.2-2.5, males time-loss RR=1.7 (95%CI, 1.0-2.9). Anatomical location differed sig. for location (p=0.03); specifically, groin (8.9% vs. 0%, thigh (27.8% vs. 28.6%, knee (17.8% vs. 4.8%, & ankle (8.9% vs. 7.1%) injuries were more frequent in males.
Edouard 2015 [25]; 17, 61% Moderate	Acute & overuse injuries in Athletics	Not included.	Sig. sex diff. for overall IR; male 110.3±6.8/1,000 registered athletes, female 88.5±6.7. Sig. sex diff. for overall outdoor IR; male 116.3±7.6/1,000 registered athletes, female 93.7±7.4. No sex diff. was found for cause & severity of injury. Sig. sex diff. time loss injury; male, 54.0±5.3, female 43.2±5.2. Sig. sex diff.; hip/groin IR male 6.9±1.9, female 3.0±1.4, thigh IR male 32.4±4.1, female 19.7±3.5, lower leg IR male 22.04±3.4, female 16.2±3.2. Sig. sex diff. stress fracture IR male 0.9±0.7, female 2.7±1.3, strain IR male 34.1±4.3, female 20.7±3.6. Overall injury male RR=1.25 (95%CI 1.13-1.37). Overall outdoor injury male RR=1.24 (95%CI 1.12 to 2.51). Male thigh injury RR=1.64 (95%CI 1.32-2.05, male lower leg RR=1.36 (95%CI 1.05-1.75) male hip/groin injuries RR=2.26 (95%CI 1.31-3.88), male muscle strains RR 1.64 (95%CI 1.33-2.04, male thigh strains RR 1.66 (95%CI 1.25-2.19, male stress fractures RR 0.32 (95%CI 0.12-0.81) than female athletes. Male sprint injury RR 1.32 (95%CI 1.06-1.66), middle distance injury RR 1.48 (95%CI 1.06-2.06), male race walk injury RR 2.55 (95%CI 1.27-5.10). Male time loss RR 1.25 (95%CI 1.07-1.46).

Edouard, 2016 [38]; 16, 57% Moderate	Acute & overuse muscle injuries in athletics.	Mean age not reported. Age groups: <20, 20-22, 23-25, 26-29, 30-34, >35. 3289 injuries in total.	1351 hamstring injuries. Overall incidence of muscle injuries sig. sex diff. Male 51.9±6.0 vs female 30.3±5.0 injuries/1000 registered athletes. Overall incidence of hamstring injuries sig. sex diff.; male 22.4±3.4 vs female 11.5±2.6 injuries/1000 registered athletes. Hamstring injury incidence in indoor training similar for both sexes; Male-0.8±0.3 vs female 0.9±0.3 injuries/1000 registered athletes. The proportion of muscle injuries sig. higher among male (45.6%) than female athletes (34.7%) ($\chi 2$=18.1; p<0.001). For male athletes, the proportion of muscle injuries was sig. higher among time-loss & in-competition time-loss injuries (about 57%) than among all, training & in-competition injuries (about 46%; p<0.05). Of 1082 injuries during 9 international athletics championships, there were 185 hamstring injuries, constituting 17.1% total injuries. Hamstring injury frequencies were sig. higher in male (19.3%) than female (13.5%) athletes ($\chi 2$=6.1; p=0.01); 61.1% (113). Muscle injuries; Male RR=1.71; (95%CI 1.45-2.01). Hamstring injuries; Male RR=1.94; (95%CI 1.42-2.66). Male hip/groin RR 3.01 (95%CI 1.54 to 5.87).
Gescheit, 2017 [75]	All injuries musculoskeletal injuries (omitting lacerations/abrasions & bruising/ haematomas) in Tennis	Male & female professional singles ranking of singles cohorts were 84±71 & 81±76, respectively. Junior & wheelchair tennis player injuries were excluded.	Female players overall IR; 201.7/10 000 GE, male 148.6 (Sig diff not reported). Female players IR 33.6±1.6/Australian Open tournament/year, male players 24.8±1.2. Most common male injury region; knee 3.5±1.6, ankle 2.3±1.3 & thigh 2.3±1.5 injuries/year. Most common in females; shoulder 5.1±1.1 injuries/year foot 3.2±1.1, wrist 3.1±1.5 & knee 3.1±1.1. No sex diff.
Hagglund 2009 [28]; 20, 71% Moderate	Acute & overuse injuries in football.	239 males (51%), 25±5 yrs (16-37), 79±6 kg. 228 females, 23±4 yrs (15-41), 63±6 kg.	Sig. sex diff. for overall training IR; Male 4.7 vs female 3.8/1000 hrs, (p=0.018) & match play male 28.1 vs female 16.1, p< 0.001). No sex diff. in severe IR (absence > 4 wks) (0.7/1000 hrs in both groups). Male players sig. great IR for 'muscle strain'; 2.6 vs 1.6/1,000 hrs & 1.0 vs 0.2/1000h. Greater proportion of hip/groin injuries in male players (18% vs 11%; p<0.02). Greater proportion of knee injuries (22% vs 16%; p<0.02) in female players (18% vs 11%; p<0.02). Greater proportion of meniscal/cartilage injury in female players (4% vs 1%; p<0.019). Greater proportion of tendon (11% vs 3%; p=<0.001) & contusion injuries (18% vs 11%; p<0.007) in male players. Greater proportion of overuse injuries (18% vs 11%; p<0.006) in female players.
Hame 2004 [166]; 18, 64% Moderate	Acute & overuse-fractures in baseball/softball, basketball, cross-country/track, golf, gymnastics, football, swimming/diving, tennis, volleyball, water	No demographic info included. Collegiate sports in the USA	Overall IR of all fractures 0.0439/athlete (95%CI 0.039-0.049). No sig. sex diff. (females 0.04038 & males 0.0461). Overall IRR=1.041 (CI, 0.917-1.422, p=0.236). Female stress fracture RR; 3.37 (95%CI, 2.11-5.38; p=0.001). Male fracture RR, 1.803 (95%CI, 1.37-2.37; p=0.001). Of 349 total primary fractures, 269 (77.1%) were fractures & 80 (22.9%) were stress fractures.

	polo, American Football.		
Hamid 2016 [29]; 18, 64% Moderate	Acute & overuse injuries & illness at Asian games.	276; 167 (60.5%) male, 109 (39.5%) female. Median 23±5 yrs.	Overall IR 30.1/100 athletes. (Athletes in individual events had higher proportion of more severe injury (37.8% vs. 12.8%)). No sig. sex diff. (p=0.28) in overall IR; male 32.9/100 athletes (95%CI 24.8 to 42.9, female 25.7 (95%CI 17.1 to 37.1). Only sig. sex diff. in IR for hockey players (p<0.001). Male hockey RR; 15 (95%CI 2.3-631.5. No sex analysis on injury type.
Harringe 2007 [30]17, 61% Moderate	All injuries resulting in >1wk absence.	42. 16 males; 21.8±1.9 yrs, 178.9±4.1 cm, 77.1±9.6 kg, gymnastics experience 15.1±3.0 yrs, training 11.0±2.0 hrs/wk. 26 females; 18.0±2.4 yrs, 161.4±7.0 cm, 54.4±6.4 kg, gymnastics experience 12.8±3.3 yrs, training 11.0±2.0 hrs/wk.	Overall IR; 2.2 injuries/1000 gymnastics hrs for males (95%CI 1.1-3.4) & females 2.2 (95%CI 1.4-3.0). No sig. sex diff. No sex analysis for anatomical location.
Hill 2019 [31]13, 46% Limited	Concussion in cricket.	555. In 2015-2016 season 278; 172 male & 106 female domestic & international players. In 2016-2017 season 277; 179 male & 98 females.	Match IR; Male 7.2 head impacts/per 1000 player days 2.3 concussions/1000 player days. Female 3.7 head impacts/1000 player days, 2.0 concussions/1000 player days. No sex analysis. Male; 32% head impacts resulted in concussion. Female; 54% head impacts resulted in concussion. 'Inclusion criteria match-only head impacts & concussions of elite-level male & female players competing in Cricket Australia-sanctioned international or domestic matches. Per 1,000 player days. Batters (male & female) sustained 75% head (helmet) impacts. Most common batting mechanism was being struck by ball being bowled by fast bowler (67% all impacts, although this mechanism did not occur in women's cricket, likely as result of comparatively slower bowling.
Hunt 2017 [137]; 16, 57% Moderate	Acute & overuse foot/ankle injuries in NCAA Div I sports.	1076 (580 males, 496 females).	Sig. sex diff. Female 4.07 vs male 3.94 injuries/1000 AE's. Female athletes sustained foot/ankle injuries at a sig. higher rate (53%) cf. with male athletes (47%) (p<0.05). Female athletes sustained a sig. higher rate of MTIs than male athletes (0.99 vs. 0.72/1,000 AE's; p<0.05). Among total injuries, female athletes accounted for a sig. higher number of bone stress injuries (23%) than males (10%) (p<0.05). Bone stress injuries that resulted in MTI 69% females vs. 31% males. Tendinopathies; 65% females vs. 35% males.
Johansen 2015 [134]17, 61% Moderate	Acute & overuse injuries in skiing.	Not reported.	Overall absolute IR; 26.4 injuries/100 athletes/season. Sig. (p<0.05) sex diff. for overall absolute IR; male 23.2 injuries/100 athletes/season, female 34.6. Sig. sex diff. for; absolute knee IR female 10.1 injuries/100 athletes/season, male 3.7 injuries, & shoulder/clavicle injuries females 6.3 injuries/100 athletes/season, males 2.5 injuries. No sex diff. for other injuries. No sig. sex diff. for relative IR male 7.5 injuries/1,000 runs, female 9.6. Absolute female knee RR 1.49 (95%CI 1.07-2.08). Relative female knee RR 2.72, (95%CI 1.35-5.51). Female shoulder/clavicle RR 2.55, (95%CI 1.06-6.14).

Kerr 2016 [20]17, 61% Moderate*	Acute & overuse injuries in cross country running.	Age 17-24 yrs. Div I - Male: 127 injuries (46%); Female: 146 injuries (54%)	Overall practice IR 5.70/1,000 AE (4.69-6.72) Female 6.52 (5.40-7.64). Overall competition IR 3.41/1,000 AE (0.68-6.13) Female 9.50 (4.85-14.16). Overall total IR 5.53/1,000 AE (4.56-6.49) Female 6.75 (5.65-7.84). Sex diff. not sig.
Kirialanis 2002 [77]17, 61% Moderate	Acute & overuse injuries in Artistic gymnastics	100 male, 13±3.2 yrs, 38.8±12.8 kg, 144.8±17 cm; 87 female, 11.5±2.3 yrs, 32.4±9.6 kg, 138.2±13.1 cm.	Overall IR 1.3/gymnast/year. Annual incidence 1.4 injuries/1000 hrs of training. No sig. sex diff. in IR (p=0.770) male 139%, female 125.2%.
Larruskain 2018 [167]; 21, 75% Moderate	Acute & overuse injuries in football.	Male 50 Age 25±4yrs, Player seasons 127, Height 182±6cm, Body Mass 76±6kg. Female 35 Age 25±5yrs, Player seasons 99, Height 167±6cm, Body Mas 59±7kg.	Sig. sex diff. for Total injury incidence; male 8.31/1000 player hrs, female 6.3 (p<0.01, training; male 4.78, female 3.43 (p<0.02) & match; male 29.86, female 22.57 (<.04). Sig. sex diff. for overuse injury; male 4.19, female 2.84 (p<0.01). Lower limb injury; male 7.33, female 5.79 (p<0.02). Hip & Groin; male 1.62, female 1.02 (p<0.05). Pubalgia; male 0.44, female 0.04 (p<0.02). Hamstring strain; male 1.52, female 0.79 (p<0.01). Quadriceps strain; male 0.44, female 0.98 (p<0.01). Muscle contusion; male 1.52, female 0.32 (p<0.01). Total injury male RR; 1.32 (95%CI, 1.09-1.59). Training injury male RR; 1.39 (95%CI, 1.06-1.83). Match injury male RR; 1.32 (95%CI, 1.01-1.73). Overuse injury male RR; 1.48 (95%CI, 1.12 1.95). Lower limb male RR; 1.27 (95%CI, 1.04-1.55). Hip & Groin male RR; 1.58 (95%CI, 1.00-2.50). Pubalgia male RR; 11.10 (95%CI, 1.48-83.44). Hamstring male RR; 1.93 (95%CI,1.16-3.20). Quads male RR; 0.44 (95%CI, 0.24-0.82). Muscle contusion male RR; 4.82 (95%CI, 2.30-10.08). IPR quads strain; male 5%, female 16% (p<0.05). Knee ligament injury; male 3%, female 9% (p<0.05). Pubalgia male; male 5%, female 1% (p<0.05). Contusion; male 18%, female 5%. Total, training, & match exposure hrs per player-season were 17%-20% higher for men cf. to women (p<0.05). Furthermore, the male team had 35% more training sessions (p<0.01) & 30% more matches (p=0.02) per wk, but the match hrs/total hrs of exposure ratio similar (p=.94). IPR ACL injury; male 1%, female 4%.
Melvin 2018 [102]; 16, 57% Moderate	Acute & overuse upper extremity injuries in ice hockey.	No demographic information reported. Div I, 620 male injuries (86%) & 104 female injuries (14%).	Div I, male overall 231.51/100,000AE (95%CI 213.29-249.74), competition IR 735.40 (95%CI 668.84-801.95), practice IR 74.01 (95%CI 62.20-85.81); female overall IR 115.22 (95%CI 93.08-137.36), competition IR 307.76 (95%CI 236.17-379.35), practice IR 49.11 (95%CI 32.36-65.87). Div I overall male RR 2.01 (95%CI 1.63-2.47).
Major 2014 [48]; 16, 57% Moderate	Acute injuries in Snowboarders.	1432; 927 male, 505 female.	Overall IR 6.4/1000 runs. No sig. sex diff.; male 6.7 female 5.9. No sex analysis by discipline or injury type. Data not reported by sex for injury type. Overall injury male RR; 1.3 (95%CI 0.9-1.7).
McCurdie, 2017 [78]	Acute & overuse injuries in tennis.	Elite players. Age not reported. 700 injuries.	Overall injury rate 20.7 per 1000 sets played; Male players (17.7 injuries per 1000 sets played) had a lower injury rate than female players (23.4 injuries per 1000 sets played).

Moreno-Perez 2019 [33]; 16, 57% Moderate	Acute & overuse injuries in tennis.	162; 119 (73%) male age 20.7±5.2 yrs, body mass 73.9±7.3 kg, average playing experience 13.3±6 yrs. 43 female (27%) age 17.9±2.7 yrs, body mass 62.9±6.8 kg, average playing experience 10.6±3.5 yrs. One season.	Overall IR 1.03/1,000 games played. Overall IR for male 1.47±3.26 & female 1.18±1.43/1,000 games. Significance diff. not reported. Lower limb most common in males (38%), Trunk most common in females (41%). Muscle strain most common diagnosis in both sexes. Sex analysis not done on IR.
Neidel 2019 [168]; 16, 57% Moderate	Stress fractures in triathlon.	86 (47 male (55%) 39 female (45%)). Age 17.5±3.3)yrs. BMI 19.9±1.4).	OR Female 2.2 0.8-6.0 (p=0.1330).
Owoeye 2017 [169]; 15, 54% Moderate	Acute & overuse injuries in football.	18-32 yr, 756 male: 356 (54%), 116 injuries. 300 female (46%), 50 injuries.	Male players overall incidence 113.4 injuries/1000 hrs (95%CI 93.7-136.0) equivalent to 3.7 injuries/match & time-loss incidence of 15.6 injuries/1000 hrs. Female players had overall injury incidence of 65.9 injuries/1000 hrs (95%CI 48.9-86.8) equivalent to 2.2 injuries/match & time-loss incidence of 7.9 injuries/1000 hrs. Male players sig. higher risk of injuries [IRR=1.72 (95%CI 1.23-2.45)].
Park 2017 [36]17, 61% Moderate	Acute & overuse injuries in fencing.	Annually, 15 elite fencers (7 male, 8 female) for each weapon category (sabre, epee foil); total 45, male 21, female 24. Athletes trained on average 4.5 hrs/day, 5 days a wk. Over the year athletes were present at training centre for 11 months (47.7 wks, totalling 1073 hrs of training).	Total IR per athlete was 3.3 injuries/year. For sabre; 3.9 injuries/year (male 4.4; female 3.5, epee 3.2 (male 3.0; female 3.4) & foil 2.7 (male 2.9; female 2.4). Overall IR across fencing; 3 injuries/1,000 hrs. Sig. sex diff. for Sabre, overall IR 3.7 injuries/1000 hrs; male 4.1 vs female 3.3 (p<0.001). Epee, overall IR 3.0 injuries/1000 hrs of training; male 2.8 vs female 3.2 (p<0.02). Foil; overall IR 2.5 injuries/1000 hrs of training; male 2.7 vs female 2.2 (p<0.004). Injury by exposure-sig. sex diff.; overall IR 13.7 injuries/1000 AE; male 14.4 vs female 13.1 (p<0.0001). Sabre, overall IR 16.5 injuries/1000 AE, male 18.4 vs female 14.8 (p<0.0001). Epee, overall IR 13.5 injuries/1000 AE, male 12.5 vs female 14.3 (p<0.002). Foil, overall IR 11.1 injuries/1000 AE, male 12.4 vs 10.1 (p<0.001).
Park 2019 [37]; 18, 64% Moderate	Acute & overuse injuries in taekwondo	283 athletes. Age>18 yrs. Athletes trained an average of 4 hrs/day, 5 days a wk. Over the course of a year, Athletes were present at the training centre for 9 months (39 wks, totalling 780 hrs of training per year. Athletes participated in nine training sessions for each period of 2 wks (4.5 training sessions/wk).	Total IR per athlete was 4.6 injuries/year, sig. sex diff. stated but numbers not reported. Sig sex diff. for featherweight & welterweight categories; female higher IR per athlete-but numbers not reported. No sig. sex diff. for flyweight or heavyweight categories. IR per 1,000 hrs 5.9 injuries/1000 hrs of training. No sig. sex diff. across any weight categories. Exposure; overall 26.1 injuries/1000 AE, with lower rates in male athletes (male 20.5 vs female 31.7 injuries/1000 AE). No sig. sex diff. in the flyweight or heavyweight categories. Sig. sex diff. in featherweight & welterweight athletes. Per 1,000 hrs of training female overall RR 1.54(0.48 to 4.97). Overall IR AE; female RR=1.55, 95%CI 0.89 to 2.68). By AE-Featherweight; female RR=1.82, 95%CI 1.05-3.14; welterweight; female RR=2.27, 95%CI 1.41-3.68. Similar distributions of affected body regions in male & female athletes (p=0.98)

Steenstrup 2014[135]; 16, 57% Moderate	Acute head injuries in alpine & freestyle skiing, snowboarding.	5247 snowboard, freestyle & alpine skiing athletes during seven seasons (2006-2013, (3203 male & 2044 female).	Sig. sex diff. (p<0.05) for overall absolute IR male 3.9 injuries/100 athletes, female 5.8. & in Freestyle male 4.5, female 7.4 & snowboard male 3.8, female 7.3. women had a higher injury incidence cf. with men, while no sig. sex diff. in alpine skiing; male 3.4, female 3.6. 1.05 (0.65 to 1.70). No sig. sex diff. overall or within disciplines for head/face injuries/1000 competition runs. Overall absolute female RR 1.48 (1.15 to 1.90). Snowboard female RR 1.93 (1.27 to 2.91). Freestyle female RR 1.63 (1.07 to 2.47). Alpine female RR 1.05 (0.65 to 1.70).
Toohey 2019 [79]; 19, 68% Moderate	Acute & overuse injuries in rugby sevens.	90; (55 male & 35 female) were under surveillance during 2-year period, over which 8457 on-field player participation hrs were completed. From the male squad 46 (83.6%) players (age 24.0±3.8 yrs) sustained 213 injuries; female squad 27 (77.1%) players (age, 22.9 6 3.1 yrs) sustained 152 injuries over 2 seasons.	Overall IR 43.2/1000 player-hrs. Sig. (p<0.05) sex diff. overall IR male 45.0/1000 player-hrs, female IR 40.8. Overall IRR 1.36; (95%CI, 1.35-1.37). No sig. sex diff. overall-male IRR 1.39; (95%CI, 0.38-1.40, female IRR 1.32; (95%CI, 1.31-1.34). Female IRR, 0.91; (95%CI, 0.90 0.91). Time-loss injuries female IRR, 0.90; (95%CI, 0.89-0.91) & non-time loss injuries Female IRR, 0.92; (95%CI, 0.91-0.94). Trunk region injury female RR, 1.75; (95%CI, 1.28-2.40; p=0.010). Head/neck region injury female RR, 0.58; (95%CI, 0.37-0.93; p=0.011). Hip/groin injury Female RR, 1.67;(95%CI, 1.22-2.28; p=0.017). Lumbar spine injury female RR, 1.91; (95%CI, 1.38-2.64; p=0.018). Head injury male RR, 0.54; (95%CI, 0.32-0.92; p=0.010). Burden of injury-male: non-anterior cruciate ligament (non-ACL) knee injuries (120-day absence/1000 player-hrs, ACL knee injuries (117-day absence, & ankle sprains (106-day absence). Female: foot sprains (157-day absence per 1000 player-hrs, ACL injuries (127-day absence-*note longer than male) & ankle sprains (118-day absence). Male hamstring strains 103 (vs female 31-day absence per 1000 player-hrs) & concussion 53 (vs female 9-day absence per 1000 player-hrs).
Traneus 2016 [170]17, 61% Moderate	Acute & overuse injuries in floorball.	122 male, 25±4.6 yrs, floorball experience 12.7±4.6 yrs, exposure floorball preseason 5.3±0.9 hrs/wk, exposure floorball game season 6.3±0.9 hrs/wk. 116 female 22±4.2 yrs, floorball experience 10.9±3.2 yrs exposure floorball preseason 5.0±0.6 hrs/wk, exposure floorball game season 6.0±0.6.	Injury incidence; male 2.6/1000 exp hrs & 3.9 female. Of 238 floorball players, 34 players (14%) sustained 38 injuries during preseason & 101 players (42%) sustained 148 injuries during game season. In total; 0.8 injuries/player. Higher proportion in female 57% than male 43% (p=0.02). Male ACL 2 injuries (1%, 11 female (6%) (p=0.02). No sig. sex diff. in injury location in pre-season. No sig. sex diff. for overuse injuries. During season sig. sex diff. in the % ankle (male 10, female 15.5; p=0.0004) knee (male 4, female 11; p=0.008) & shoulder (4 male, 0.5 female; p=0.04) injuries. Across full season, sig. sex diff. in % ankle (7.5 male, 20 female; p=0.0003) & knee injuries (male 7, female 15.5; p=0.007). Sig. sex diff. for traumatic injuries in % ankle (5.5 male, 15 female; p=0.001) & knee (3 male, 11 female; p=0.001).
Westerman 2015 [110]; 16, 57% Moderate	Acute & overuse injuries in gymnastics.	119, male 64, female=55. No further demographic info included.	Overall IIR female 9.37/1,000 AE male 8.78. No sig. sex diff. Sig sex diff. for; Neck clavicle-male 0.59, female 0.14, Wrist/hand/finger/thumb-male 2.12, female 0.61, Hip/groin/thigh-male 0.07, female 0.65, Ankle/Foot/heel/toe-male 1.54, female 3.64. Neck clavicle-female RR 0.24. Wrist/hand/finger/thumb-female RR 0.29. Hip/groin/thigh-female RR 8.92. Ankle/Foot/heel/toe-female RR 2.37. Symptom resolution for all symptoms was categorized as 1 hour, 0.1 hour to 1 day, 0.1 day to 3 days, 0.3 days to 1 wk, 0.1 wk to 2 wks, 0.2 wks to 4 wks, & 0.4 wks. We classified SRCs that had a

			symptom resolution time over 4 wks as having a long symptom resolution time.
Wolf 2009 [111]17, 61% Moderate	Acute & overuse injuries in swimming.	94 swimmers; 44 male, 50 female. Divs. I college swimmers.	Overall IIR male-4.00 injuries/1000 AEs vs. female 3.78 injuries/1000 exposures not sig. No sig. sex diff. by injury location or discipline (Sprint vs. distance) or stroke (freestyle, fly, breaststroke, backstroke). Overall male RR, 1.33 (0.81-1.37).
Yang 2012 [268]; 18, 64% Moderate	Acute & overuse injuries in baseball, basketball, cross-country & track & field, football, gymnastics, swimming & diving, wrestling, rowing, football, softball, volleyball.	573 injured athletes; 319 male & 254 female.	Sex comparable sports sig. sex diff. overall; acute IR male 30.4 vs female 27.3/10 000 AE's (p<0.0001). Overuse IR female 16.8 vs male 14.9 per 10 000 AE's (p<0.0001). The highest overuse IR was in female field hockey 70.5/10 000 AEs. The highest acute IR across sports was in female football, with 190.0/10 000 AEs. No sex diff. in types of overuse injuries in 10 sex-comparable sports. RR for acute vs overuse injury higher among male athletes; 3.67 (95%CI=3.02, 4.46) than female athletes; 1.53 (95%CI=1.28, 1.83). Male athletes had a lower proportion of sprains & strains (60.1% vs. 66.6%, p=0.0465) & a higher proportion of open wounds (8.1% vs. 3.5%, p=0.0044). Male athletes sustained more major injuries (34.0% vs 26.8%) & fewer no-time-loss injuries (27.2% vs 45.9%) (p=0.0021). Sex diff. in injury severity for overuse injuries; proportion of major injuries incurred by male athletes almost twice that of females (45.9% vs 23.1%, p<0.0001) in 16 study sports & 10 sex-comparable sports (49.0% vs 29.4%, respectively, p=0.0002).
Zupon 2018 [113]; 15, 54% Moderate	Back, neck & spine injuries in ice hockey.	College age 17-22 yrs. Demographic data not included. Men's ice hockey data: 39 Division I programmes provided 87 team-seasons. Women's ice hockey data: 13 Division I programmes provided 31 team-seasons.	Male competition IR 1.22 (95%CI 0.95–1.50), practice IR 0.23 (95%CI 0.16–0.30), overall IR 0.47 (95%CI 0.39–0.55). Female competition IR 0.84 (95%CI 0.44–1.24), practice IR 0.24 (95%CI 0.11–0.37), overall IR 0.40 (95%CI 0.26–0.54). No sig. sex diff.

OR: odds ratio; aOR: adjusted odds ratio; CI: confidence interval; HR: hazard ratio; IRR: incidence rate ratio; RR: relative risk; IQR: interquartile range.

Table 6 Participant characteristics and main findings for the Tier-3 athlete studies.

Reference & Quality score	Focus	Participants characteristics, age (mean±SD)	Findings/Comment
ADULTS			
Chan 2021 [141]; 17, 61% Moderate	Severe foot injuries in 25 NCAA sports.	NCAA data: 2004-2005 to 2008-2009 & 2009-2010 to 2013-2014. 3,607 injuries included. College age 17-22yrs. Demographic data not included.	Overall IIR 30.62/100,000 AEs. Among all foot injuries, the operative rate was 4.6%, the season ending rate 6.9%, & the career-ending rate 1.0%. Male sports with the highest foot IIR football 56.20, cross-country 38.91, basketball 38.77, & American Football IIR 34.98. Female sports with the highest foot IIR gymnastics 88.58, cross-country 52.88, football 46.48, & outdoor track 46.28. Overall severe IIR; female (5.89), male (5.64). Male sports with highest severe foot IIR basketball 10.71, indoor track 7.16, & American Football 7.08. Female sports with highest severe foot IIR cross-country 17.15, gymnastics 14.76, & outdoor track 14.65. Sex diff. in operation rate for severe foot injury (male RR 2.43; 95%CI 1.71-3.44). Sex diff. in season ending injuries (male RR 1.89; 95%CI 1.48-2.41). Severe injuries sustained by male athletes were more likely to be due to contact than in female athletes (RR 2.23; 95%CI 1.76-2.83). Male sports contact (v non-contact) injuries RR 1.56 (95%CI 1.39-1.75). Female sports contact (v non-contact) injuries 0.43 (95%CI 0.34-0.55).
Chandran 2016 [87]; 15, 54% Moderate	Acute & overuse injuries in football.	18,239 injuries included. College 17-22 yrs. Demographic data not included.	Over 2004-09; Overall IR female 7.3, male 7.6/1,000 AE's ($p<0.05$). New injuries IR female 6.3, male 6.7/1,000 AE's ($p<0.05$). Contact injuries (no significant difference). Non-contact IR female 2.7, male 2.9/1,000 AE's ($p<0.05$). Game IR female 14.3, male 17.1/1,000 AE's ($p<0.05$). Practice IR female 5.0, male 5.0/1,000 AE's (no significant difference). Short term IR female 4.1, male 4.5/1,000 AE's ($p<0.05$). Long term injuries (no significant difference). Injuries requiring surgery IR female 0.19, male 0.12/1,000 AE's ($p<0.05$). Overall female RR 0.95. New injuries female RR 0.94. Non-contact injuries female RR 0.91. Game injuries female RR 0.84. Short term injuries female RR 0.91. Injuries requiring surgery female RR 1.63.
Comeau 2023 [142]; 20, 71% Moderate	Acute & overuse injuries in ice hockey, basketball, football, wrestling, & volleyball, American Football (male only) & rugby (female only).	295, 182 male & 113 female varsity athletes attending a single Canadian University. Males 21.0±2.3 yrs, 184.2±8.2 cm, 90.5±17.6 kg, BMI 26.6±4.6 kg/m2. Female 20.1±2.2 yrs, 169.6±7.3 cm, 69.9±10.6 kg, 24.3±3.1 kg/m2.	Total proportion of athletes reporting one or more injuries, male 68.7%, females 68.1% (NS). Greater proportion female wrestlers (100%) with at least one acute injury cf. to male wrestlers (40.0 %) ($p<0.05$). No sex diff. for chronic injuries across sports. Greater proportion of athletes sustained an acute injury cf. to chronic injury within each sex overall. Overall IR no sex diff.; female 1.4 injuries/athlete, male 1.4/athlete. Hockey; male 2.1, female 1.5 ($p<.05$), basketball; female 2.4, male1.5 ($p<.05$) & football; male 1.6, female 0.6 ($p<.05$). Most common injury locations were hip, groin, or thigh & lower leg, ankle or foot for both male & female athletes. Sig. higher proportion of female wrestlers experienced shoulder injury (62.5%) cf. to male wrestlers (0.0%). Sig. higher proportion of female basketball players experienced an injury to hip, thigh, or groin (50.0%) cf. to male players (6.7%). Male football players (40.0%) reported a higher proportion of hip, thigh, or groin injuries cf. to female football players (4.5%). Sig. higher proportion of male football players (50.0%) sustained a muscle/tendon injury cf. to female football players (18.2%). Overall, male & female athletes did not differ sig. in mean number of events a player missed due to injury (male=4.8, female=5.4). When cf. on sport-by-sport basis,

			female athletes missed more events cf. to respective male team in hockey (female=11.1, male=2.1, p<0.05), basketball (female=6.4, male=3.1, p>0.05) & volleyball (female=9.3, male=4.3, p>0.05). Mean time to injury as percentage of competitive season overall male 32.3%, female 28.9 % (NS), basketball male 42.6 % or 67 days, female 17.9 % or 28 days (p<.05), & volleyball male 41.2% or 65 days, female 8.8% or 14 days (p<.05). Time to concussion or head trauma differed between males & females (collapsed across sport) where females had sig. shorter time to concussion cf. to males (p<0.5).
Covassin 2003 [88]; 17, 61% Moderate	Concussion in football, lacrosse, basketball, softball/baseball & gymnastics.	College age 17-22yrs. Demographic data not included.	Concussions accounted for 6.2% all reported injuries. Highest percentage of concussion: female lacrosse players (13.9%) in game followed by female football (11.4%), male ice hockey (10.3%), male lacrosse (10.1%), football (8.8%), female basketball (8.5%). Male incidence of concussion higher in practice, female concussion incidence higher in games. Football game injuries - Female 2.04/1,000 AE vs. Male 1.10/1000AE. Lacrosse game injuries - Female 1.37/1000AE vs. Male 1.41/1000AE. Basketball game injuries - Female 0.54/1000AE vs. Male 0.29/1000AE. Softball/baseball game injuries - Female 0.34/1000AE vs. Male 0.43/1000AE. Gymnastics competition injurie - Female 0.11/1000AE vs. Male 0/1000AE. Female concussion higher (p<0.01) in games than practice in; lacrosse (IDR 3.26), football (IDR 14.57), basketball (IDR 2.35), field hockey (IDR 1.59). Male concussion higher (p<0.01) in games than practice in; hockey (IDR 17.35), lacrosse (IDR 10.07), football (IDR 13.75), basketball (IDR 2.07), baseball (IDR 5.38).
Covassin 2016 [42]; 18, 64% Moderate	Concussion in football, basketball, ice hockey, lacrosse, softball, baseball.	Male: 779 concussions (46%) Female: 903 concussions (54%). Some athletes and multiple concussions. College age 17-24 yrs. Actual number of athletes not reported.	In sex comparable sports, sex diff. (p<0.05) in; softball/baseball female IR 2.34/10,000AE's, male IR 1.20, basketball female IR 4.67, male IR 3.34, football female IR 6.45, male IR 4.19. No sig. diff. in ice hockey female IR 6.57 male IR 5.94 or lacrosse female IR 4.99, male IR 5.44. Baseball/softball female RR=1.95, (95%CI=1.45-2.65), Basketball female RR=1.4 (95%CI=1.17-1.67), Football female RR=1.54 (95%CI=1.31-1.83), Ice hockey female RR=1.1 (95%CI=0.84-1.30), Lacrosse male RR 1.1 (95%CI=0.832-1.43). Females typically had greater time loss from sport following concussion than male athletes in both training & competition related injuries. In this study only by 1-3 days.
Cross 2010 [89]; 16, 57% Moderate	Acute & overuse hamstring injuries in Football, field hockey, American Football, tennis, cross country	NCAA athletes Age 17-24 yrs. Specific age not reported. Male: 1277 injuries (81% injured) Female: 299 injuries (19%)	Overall hamstring strain male IRR = 1.62 (95%CI 1.28-2.05). Highest IR in male sports; football (6.91 injuries/10,000 athlete-exposures [AEs]) & American Football (6.04/10,000 AEs). Highest IR in female sports; football 3.81 injuries/10,000 AEs & field hockey 3.79/10,000 AEs.

Cross 2013 [90]; 17, 61% Moderate	Acute & overuse hamstring injuries in football.	519 injured athletes. 309 male injuries (59%), 210 female injuries.	Sex diff. (p<0.05) in; overall IR male 0.58/1,000 AE's, female 0.37, game IR, male 1.2, female 0.5, practice IR, male 0.41, female 0.31 & during in-season males 0.49, female 0.25. No sig. sex diff. in injury rates during preseason. Male athletes had higher proportion of recurrent hamstring strains than female athletes (Male, 22%, female 12%; p=0.003). Overall Male IRR 1.64 (95%CI 1.37-1.96), game male IRR 2.42 (95%CI 1.82-3.23), practice male IRR 1.34 (95%CI 1.06-1.68), in-season male IRR 1.98 (95%CI 1.56-2.52). Preseason male IRR 1.04 (95%CI 0.79-1.37).
Dalton 2015 [91]; 17, 61% Moderate	Acute & overuse hamstring injuries in American Football, wrestling, volleyball, field hockey, gymnastics, ice, hockey, football, basketball, lacrosse, baseball/softball, indoor & outdoor track, cross country, tennis, swimming & diving.	No demographic info. reported. 1142 injuries reported	Overall IR 3.05/10,000AE's. Overall competition IR 5.24/10,000AE's, overall practice IR 2.56/10,000AEs. Overall competition RR = 2.05 (95%CI, 1.81-2.32). American Football, men's football & women's football contributed greatest number of hamstring strains (35.3%, 9.9% & 8.3% respectively). Sex analyses: football overall male RR=1.60 (95%CI 1.22-2.11), male competition RR=1.96 (95%CI 1.29-2.98), male practice RR=1.46 (95%CI 1.02-2.10). In women's football, preseason rate higher than in-season/postseason (RR=2.01 [95%CI 1.33-3.04]). No sig. diff. found in males across the season. Basketball overall female RR=2.05 (95%CI 1.19-3.53) practice female RR=2.56 (95%CI 1.30-5.05). In women's basketball, preseason rate higher than in-season/postseason (RR=3.07 95%CI 1.61-5.86). No sig. diff. found in males across the season. Baseball/softball overall male RR = 1.66 (95%CI 1.07-2.59), competition male RR=4.51 (95%CI, 2.90-6.12). Indoor track overall male RR=1.88 (95%CI, 1.26-2.78) practice male RR=2.37 (95%CI, 1.46-3.85).
Deckey 2020 [144]; 18, 64% Moderate	Hand & wrist injuries in basketball.	NCAA database 2009-14. College age 17-22yrs. Demographic data not included.	Hand & wrist injuries IIR female 4.20/10,000 AEs, male 7.76. Female competition (cf. to practice) IRR 2.40 (95%CI 1.54-3.72) male competition (cf. to practice) IRR 3.31 (95%CI 2.45-4.47). Female preseason IPR (cf. with male) 0.47 (95%CI 0.26-0.85); female in-season IPR (cf. to male) 0.59 (95%CI 0.44-0.80). Guards had the highest IIR. Female guards IRR 1.19 (95%CI 0.83-1.72). Female centres IRR 0.89 (95%CI 0.41-1.92) female forwards IRR 0.61 (95%CI 0.36-1.06). Contact injuries were the most common injuries in females (96.0%) & males (90.1%) (NS).
Deckey 2020 [143]; 15, 54% Moderate	Neck & cervical spine injuries.	NCAA data from 2009-14. Across 22 sports.	Overall IIR 7.05/100,000 AEs. In sex-comparable sports, male IIR 2.66/100,000 AEs, female IIR 1.95/100,000 AEs. In male sports, American Football had the highest IIR 29.09/100,000 AEs. In female sports, ice hockey had the highest IIR 11.51/100,000 AEs. Overall IIR was higher during competition (17.90) than practice (4.54) per 100,000 AEs). Competition RR 3.94 (95%CI 3.27-4.75). In sex comparable sports, male competition (v practice) RR 3.34 (95%CI 2.04-5.46), female competition (v practice) RR 5.57 (95%CI 2.96-10.49). Gymnasts female competition (v practice) RR 29.81 (95%CI 2.70-328.75). Contact comprised the largest proportion of neck & cervical spine injuries (n = 9576, 83.2%) in all sports. Among sex-comparable sports, contact mechanism was evident in male sports 63.1%, & female sports 84.6%. In sex-comparable sports, female contact RR 1.34 (95%CI 0.88-2.05), male non-contact RR 4.25 (95%CI 1.06-16.98). In sex comparable sports, 73.4% male athletes (n=1,147) returned to play within 24 hrs, & 53.2% female athletes (n=613) returned to play within the same time frame. Male athletes 1.38 times more likely than female athletes to return to play within 24 hrs of injury (IPR 95%CI 0.79-2.41). In sex comparable sports,

			strains/contusions were most common in both male & female athletes (71.7% & 96.1%, respectively).
Eckard 2017 [92]; 16, 57% Moderate	Quadriceps strain in American Football, wrestling, field hockey, gymnastics, volleyball, baseball/softball, basketball, cross country, ice hockey, lacrosse, football , swimming & diving, tennis, track.	414, Collegiate age athletes. 116 male (28%), 298 female.	Overall IIR 1.07/10,000 AE's. In sex-comparable sports; overall IIR female 1.97/10,000 AEs vs male 0.65 (p<0.05); RR 3.03 (95%CI 2.45-3.76). Sig. diff. (p<0.05) in sex comparable sports; pre-season female 4.46/10,000AE vs male 1.08/10,000AEs; female RR 4.32 (95%CI 3.12-5.99), the regular season female 1.08/10,000AE vs male 0.53/10,000AEs, in competition female 1.79/10,000AE vs male 1.11/10 000 AEs; RR 1.61 (95%CI 1.08-2.41) & in practice female 2.02/10,000AE vs male 0.53/10 000 AEs; Practice female IRR 3.81 (95%CI 2.94-4.94). Sport specific; regular season IIR baseball/softball female 1,19/10,000AE vs male 0.35/10,000AE's & indoor track female 2.19/10,000AE vs male 0.69/10,000AE's. Sport specific; regular season baseball/softball female RR 3.41 (95%CI 1.25-9.30) & indoor track female RR 3.18 (95%CI 1.17-8.62).
Eckard 2017 [93]; 16, 57% Moderate	Acute & overuse hip/groin injuries in American Football, wrestling, volleyball, field hockey, gymnastics, ice, hockey, football, basketball, lacrosse, baseball/softball, indoor & outdoor track, cross country, tennis, swimming & diving.	No demographic info. reported.	Overall hip flexor IR 1.60/10,000 AEs. The sports with the highest rates of hip flexor strains were men's (3.77/10,000 AEs) & men's ice hockey (2.47/10,000 AEs). Overall adductor IR 1.29/10,000 AEs. The sports with the highest rates were men's (3.15/10,000 AEs) & men's ice hockey (2.47/10,000 AEs). Sex-comparable sports; no sig. sex diff. for hip flexor IR; male 1.81, female 1.59/10,000 AEs. Hip adductor IR sig. higher in male (1.71) than female (1.15/10,000 AEs). Hip flexor; overall male IRR 1.14 (95%CI 0.96-1.36); male IRR 1.68 (95%CI 1.19-2.37); baseball/softball male IRR 0.44 (95%CI 0.20-0.98). Hip adductor; overall male IRR 1.49 (95%CI 1.22-1.81); ice hockey male IRR 1.83 (95%CI 1.13-2.96) & football male IRR 1.83 (95%CI 1.25-2.69). Noncontact mechanism hip flexor strain male IPR 1.03 (95%CI 0.88-1.21, hip adductor strain male IPR 0.99 (95%CI 0.85-1.16). Overuse represented the second-largest proportion of injuries among hip flexor strains (23.4%, 180) & hip adductor strains (18.4%, 114). Overuse hip flexor strain female IPR 1.45 (95%CI 1.10-1.92). Overuse hip adductor strain male IPR 1.07 (95%CI 0.73-1.56).
Fares 2019 [74]; 18, 64% Moderate	Acute & overuse injuries (sustained in fight but not resulting KO or TKO were excluded) in mixed martial arts & ultimate fight championship.	285 UFC matches included 291 injuries documented from all nine weight divisions. Of 285 matches, 249 (87%) involved male fighters, 36 (13%) involved female fighters.	Decision was the most common way a match ended in both male (48%) & female (50%) fights. KO/TKOs were sig. (P = 0.0007) higher in matches involving male fighters (36%) (female fighters 14%). Submissions were sig. (p=0.001) higher in matches involving females (36%) (males 16%). Overall injury rate 51/100 AE. Head injuries were the most common; overall head IR rate 34/100 AE (male 28/100AE, female 29/100AE), lower limb overall IR 9/100 AE (male 8/100AE, female 2/100AE; p<0.001), upper limb 8/100 AE (male 6/100AE, female 19/100AE; p<0.0003). Male IR 54/100 AE, female IR 30/100 AE (sig not reported).

		No further info. reported.	
Fraser 2021 [145]; 18, 64% Moderate	Lateral ankle sprains in military athletes.	Injury data for 272,970 enlisted male tactical athletes, 56,732 enlisted female tactical athletes, 24,534 male officers, & 6020 female officers included from 2006-15.	Overall IR male tactical athletes 27.9/1000 person-yrs, female tactical athletes 34.5/1000 person-yrs, male officers 12.6/1000person-yrs, & female officers 16.4/1000 person-yrs. Female enlisted RR 1.24 (95%CI 1.23-1.25; p < 0.01). Female officers RR 1.30 (95%CI 1.27-1.34; p < 0.01).
Fulstone 2016 [94]; 15, 54% Moderate	Acute knee Injury in football.	8116 athletic injuries; 1,083,752 AE's. 556,558 female AE's, 527,194 male AE's. No demographic data reported.	11% Division I teams, 5% Division II & 8% Division III teams participated. To preserve statistical power, Division II & III teams pooled for analyses. Division I athletes contributed 467360 AEs & Division II/III athletes contributed 616, 393 AEs. Overall IR 7.5/1000 AEs (all injuries), overall knee injuries 1.06/1000 AEs. Sex diff. (p<0.05) overall; female 1.19/1,000 AE's & male 0.91/1,000 AE's. Overall female RR 1.31, (95%CI 1.16-1.47). Overall female OR 1.61 (95%CI 1.00-2.58). Time lost from participation sig. higher in females (p<0.05). Female OR 1.44 (95%CI 1.27-1.63). Rate of knee injuries in Division I players higher than in Division II/Division III players (RR 1.20 95%CI 1.07-1.35). After adjusting for contact & level of competition, female OR 1.44 (95%CI 1.27-1.63). Contact (v non-contact) also a sig. predictor of knee injury OR 1.20 (95%CI 1.05-1.37), event type & level of competition did not.
Gessel 2007 [95]; 18, 64% Moderate	Concussion in American Football, football, volleyball (excl. from discussion, basketball, wrestling, baseball/softball).	14-24 year olds. 396 high school concussions; 482 collegiate concussions	Overall concussion IIR 0.23/1000AE's. Practice IIR 0.11/1000AE's, competition IIR 0.53/1000AE's. Highest IIR-Collegiate American Football 0.61/1000AE & collegiate girls' football 0.63/1000AE. Football; female IIR 0.36/1000 AEs, male 0.22/1000 AEs (p=0.03), RR 1.68 (95%CI 1.08-2.60). Basketball; females IIR 0.21/1000 A-Es vs males 0.07/1000 A-Es (p=0.01), RR 2.93 (95%CI 1.64-5.24). Football concussion as proportion of total injuries; females 15.1% vs. male 9.4%; IPR 1.61 (95%CI 1.59-1.64). Basketball concussion as a proportion of total injuries female 11.7% vs. male 3.8%; IPR 3.09 (95%CI 2.98-3.20). Male symptom resolution & return to play quicker than female in high school basketball. Greater proportion baseball players males returned within 6 days than softball players females.
Haines 2022 [146]; 14, 50% Moderate	Acute & overuse injuries in equestrian.	327,912 (91.51%) female, 30,407 (8.48%) male athletes. 148,530 (33.47%) junior equestrian athletes, 295,200 (66.53%) senior athletes. Data from 2015-19. No other	Overall IIR across all equestrian disciplines 780 injuries/100 000 AE. IR per discipline was less than 1.2%; 3-day eventing 1.18%, hunter–jumper 1.11%, western 0.06%. Most common injury types in 3-day eventing & hunter jumper were 'possible head injury' & 'fractures & bone injuries,' followed by 'muscle & tendon' injuries. These were also the most common injury types over all disciplines. 779 injury reports (23%) that had no injury type filled out on the form that were filed into the 'uncategorized' injury type. Male IR 0.84% & Female IR 0.97% (p<0.001). 23.8% participants did not have a sex specified, so these results are only based on 76.2% participants. Senior IR 0.70%, junior IR 0.91% (p<0.001).

		demographic info included.	
Harmer 2008 [174]; 16, 57% Moderate	Thigh, knee & ankle acute & overuse injuries in fencing.	78,223 competitors (male=60.7%; female=39.3%). Age 8-70+, participated in various events in the targeted competitions. Over 5 seasons; 184 time-loss injuries were recorded.	Overall IIR 0.3/1,000 AE's. No sig. sex diff. in overall IIR-male 0.27 (95%CI=0.22-0.32) vs female 0.36 (95%CI=0.29-0.44). Female time loss injury overall RR=1.35; (95%CI=1.01-1.81). Female fracture RR 2.6 not sig. No sig. sex diff. for any injury by anatomic location. Similar profiles for most common type-by location injuries: thigh strains (Female 14%, male 14.3%) & ankle sprains (Female 11.6%; male 13.3%). Acute & overuse not reported separately.
Hassebrock 2019 [96]; 17, 61% Moderate	Acute & overuse lower back & lumbar spine injuries in American Football, wrestling, baseball; women's volleyball, field hockey, gymnastics, & softball; & men's & women's ice hockey, football, basketball, lacrosse, indoor track & field, outdoor track & field, cross-country, swimming & diving, & tennis.	No demographic info included. NCAA athletes; age 17-23	Overall IR 6.01/1000AE's (95%CI 5.62-6.39). In sex-comparable sports, males had sig. higher IR overall than females (4.94 vs 3.94/1000 AEs). In specific sports; males sig. higher IR than females in lacrosse (8.02 vs 1.86) & basketball (4.58 vs 2.64). In sex-comparable sports, male IRR 1.25 (95%CI, 1.05-1.48). Within specific sports; male IRR in Lacrosse 4.31 (95%CI 2.07-8.96) & basketball, 1.73 (95%CI 1.17-2.54).
Hibberd 2016 [97]; 17, 61% Moderate	Shoulder-AC joint injury in American Football, wrestling, baseball; women's volleyball, field hockey, gymnastics, & softball; & men's & women's ice hockey, football, basketball, lacrosse, indoor track & field, outdoor track & field,	No demographic info included. College age athletes 17-23 yrs	AC joint sprain overall IIR 1.72/10,000 AEs. Sig diff in sex-comparable sports; overall IIR male 1.85 vs. female 0.40. In soccer; overall IIR male 1.19 vs. female 0.52 & competition male 3.86 vs. female 1.83. Ice Hockey IIR male 6.40 vs female 2.12. Lacrosse overall IIR male 1.57 vs female 0.14, competition IIR male 4.3 vs. female 0.36, practice IIR male 1.03 vs. female 0.08. In sex-comparable sports; male RR 4.67 (95%CI 3.56-6.14). In football overall male, RR 2.30; (95%CI 1.18-4.46) & male competitions RR 3.14; (95%CI 1.34-7.34) & No sig. male practice RR 1.58 (95%CI 0.53-4.69). Ice Hockey-overall male RR 3.01 (95%CI 2.08-4.37), competition male RR, 3.11 (95%CI 2.09-4.64) & male practice RR 4.08 (95%CI 1.47-11.32). Lacrosse-overall male RR 11.61 (95%CI 2.79-48.37) male competition RR 12.08 (95%CI 1.60-91.42) male practice RR 12.30 (95%CI 1.64-92.12). In sex-comparable sports; Injuries due to player contact; male IPR 1.50 (95%CI 1.06-2.13), surface contact; female IPR, 1.55 (95%CI 1.01-2.38).

	cross-country, swimming & diving, & tennis.		
Hurtubise 2015 [98]; 16, 57% Moderate	Acute severe injury in American Football (m) rugby (f) basketball, volleyball, , ice hockey, cross country/track & field.	NCAA athletes- typically aged 17-24 yrs. 1,155 male injuries (70% injured), 502 female injuries	Overall female OR; 1.40 (CI 1.05-1.86). Female concussion OR 1.85 (CI 1.28-2.67). Sig. greater proportion of all injuries are concussion in female athletes 11% vs. male 6.2% (p<0.001). Female had sig. higher proportion of severe injuries (17.7%) than males (13.3%) (p=0.02).
Hopkins 2022 [147]; 18, 64% Moderate	Recurrent injuries in track & field.	NCAA database 2009-14. College age 17-22yrs. Demographic data not included.	Overall, 474 injuries, 13.1% classified as recurrent injuries. T&F athletes missed average 15.6 days following initial injury & 24.2 days following recurrent injury. T&F athletes missed 55% (95%CI 17-107; p<0.01) more time following recurrent injury than initial injury. When stratified by sex, diff. was greater in women's T&F; recurrent injuries 75% (95%CI 16-167; p<0.01) more time loss than initial injuries cf. to men's T&F; recurrent injuries 34% (95%CI 9-96; p=0.14) more time loss than initial injuries. No sex diff. in proportion of injuries classified as recurrent (IPR 0.96 [95%CI 0.7-1.3]), however, women's T&F athletes experienced 27% (95%CI 5-55; p=0.02) more time loss across all injuries than men's T&F athletes. Recurrent injuries (cf. to new injury) time loss RR 1.50 (95%CI 1.13-1.98; p<0.01), female (cf. to male) time loss RR 1.15 (95%CI 0.96-1.41; p=0.18). (i.e., time loss is due to recurrence not sex).
Kerbel 2018 [99]; 16, 57% Moderate	Acute & overuse Hip/groin Injuries in football, ice hockey, cross country, basketball, tennis, track, gymnastics, lacrosse.	No demographic info included.	Overall hip injury rate of 53.06/100,000 AE's. Sports with highest hip IR/100,000 AE's; male football (110.84, male ice hockey (104.90, female ice hockey (76.88). Sig. sex diff.; overall male 59.53/100,000AE's female 42.27. Proportion of injuries due to player contact male 17.0% vs female 3.6% (p<0.05); Overuse/gradual female 29.1% vs male 16.7% (p<0.05). NTL injuries; female 62.5% vs male 54.2% (p<0.05). Overall Game RR, 2.18 (95%CI, 1.99-2.39). Overall male RR, 1.41 (95%CI, 1.28-1.55). Female practice RR, 1.00 (95%CI, 0.82-1.21) conversely male competition RR 3.14 (95%CI, 2.82-3.50). Player contact male IPR, 4.80 (95%CI, 3.10-7.42). Overuse injury female IPR, 1.74 (95%CI, 1.46-2.06). NTl female IPR, 1.15 (95%CI, 1.07-1.25).
Kerr 2015 [100]; 16, 57% Moderate	Acute & overuse injuries in swimming & diving. RIO database 2008-19.	9 male & 13 female swimming/diving programmes included. No other demographic info included.	No sig. sex diff. for Overall IIR-training, competition, swimming or diving injuries. Sig. sex diff. for overuse injuries in swimming; female 1.04/1000 AEs, male 0.66/1000 AEs. Male divers sustained a greater proportion of shoulder injuries (32.0%) than female divers (5.4%). Swimming overuse female RR 1.58; (95%CI 1.14 to 2.19). Diving shoulder injury male IPR 5.92 (95%CI 1.37-25.59).

Kerr 2016 [20]; 17, 61% Moderate*	Acute & overuse injuries in cross country running.	Age 17-24 yrs. 89 male injuries (44%), 114 female injuries (56%) (Div II & III)	Div II - overall practice IR male 1.62/1,000AAE (0.77-2.47), female IR 1.96 (0.85-3.07). Overall competition IR male 2.82/1,000 AE (0.00-6.74), female IR 6.41 (0.00-13.66). Total overall IR male 1.71/1,000 AE (0.87-2.55), female 2.28 (1.13-3.43). Div III - overall practice IR male 5.14 (3.88-6.40), female 6.13 (4.85-7.40). Competition IR male 5.77/1,000 AE (2.00-9.53), female 5.77 (2.19-9.34). Total overall IR male 5.21/1,000 AE (4.01-6.41), female 6.09 (4.89-7.29). Sig. sex diff. for hip/groin IR female 0.65/1000AE, male 0.15/1000 AE; RR 4.32 (95%CI 1.89-9.85). Ankle IR male 0.60/1000AE, female IR 0.29; RR 2.07 (95%CI 1.07-3.99). Overall female RR 1.25 (95%CI 1.05-1.50). Largest proportion of severe injuries male: trunk (16.7%), hip/groin (14.3%), & lower leg (13.2%); Female: trunk (22.7%), foot (22.5%) & thigh (18.4%). Largest proportion of severe injuries; male stress fractures (30.0%), strains (11.6%) & spasms (11.1%); female fractures (60.0%), stress fractures (58.3%) spasms (11.1%).
Kronisch 2002 [178]; 20, 71% Moderate	Acute fractures in mountain biking.	93; (71 male, 22 female). Male mean age 28.4 yrs (range 15-59), height 181 cm (range 156-195), & weight 72.9 kg (range 54-100). Female mean age 30.8 yrs (range 22-52), height 167 cm (range 151-182), &weight 58.3 kg (range 51-66). Females with fractures had a mean age of 30.8 yrs, & those without fractures had a mean age of 30.8 yrs. Males with fractures had a mean age of 31.2 yrs, & those without fractures had a mean age of 27.6 yrs.	For all events combined, female IR; 0.77% vs. male 0.40% (p=0.01). Female downhill IR; 0.76% vs. male 0.40% not sig. Female DS IR; 1.61% vs. male 0.40% (p=0.02). No sig. sex diff. in CC race over the 8-year study period. Female fracture IR downhill; 0.51% vs. male 0.11%, (p<0.02, Female dual slalom 0.96% vs. male 0.10%, (p<0.02, female overall fracture IR 0.35% vs. male 0.08%, (p<0.001). The diff. between the female fracture IR CC, downhill, dual slalom (0.17% vs 0.51% vs 0.96%, p 0.04). Overall Injury female OR; 1.94 overall female fracture OR; 4.17. Female fracture downhill OR; 4.78. Female fracture dual slalom OR; 9.64. Fractures sustained by higher percentage of females than males (45.5% vs 21.1%, p<0.03).
Lacasse 2021 [148]; 11, 339% Limited	All injuries in college football.	One season (2019) College age (17-24 yrs). No other demographic info included. N=27 male players, n=34 female players.	69.35% injuries female players, 30.65% male players (p=0.031).

Lanzi 2017 [179]; 15, 54% Moderate	Shoulder-posterior gleno-humeral instability injuries in rugby, wrestling, track, judo, swimming, gymnastics, American Football, ski, baseball, handball, lacrosse, fencing, paintball, cheerleading.	No specific demographic info reported. Retrospective cohort study (2006-2012) within the population at the US Military Academy using Cadet Illness & Injury Tracking System (CIITS). Data from 113 posterior instability injuries analysed (105 male, 8 female).	Overall IR 4.28/1000 person-yrs or 0.08/1000AE's. Sig. sex diff. overall; male IR of 4.67/1000 person-yrs, female IR 2.04/1000 person yrs (p<0.05). Intercollegiate athletes overall IR; male 9.01/1,00py, female 4.18 (p<0.04) IR; male 0.08/1,000 AE's, female 0.04 (p<0.06). Overall male IRR 2.29 (95%CI 1.11-4.69). Intercollegiate; population based male IRR of 2.3 (95%CI 1.04-5.08; p=0.04), exposure based IRR of 2.14 (95%CI 0.97-4.74; p=0.06).
Lievers 2020 [149]; 18, 64% Moderate	Foot injuries in multiple NCAA sports.	College age 17-22yrs. Demographic data not included. 2009-15.	Overall highest foot IIR in gymnastics (10.62/10,000AE), lowest IIR were in female (0.70) & male (0.61) swimming & diving. In sex comparable sports, sex diff. in Track & field female 4.92/10,000AE, male 3.29; male foot injury RR 0.67 (95%CI 0.50-0.89; p=.0039). No sex diff. in injury types across or within sports (foot/toe contusion, midfoot injury, plantar fascia, turf toe, metatarsal fracture, forefoot extensor/flexor tear).
Marchena-Rodriguez 2020 [59]; 18, 64% Moderate	Acute & overuse injuries in badminton.	150 players, 69.33% male. Overall 50.18±10.72 yrs, male 50.18±10.72, female 51.58±12.95, BMI 25.56±3.36 kg/m2, male 25.56±3.36, female 23.78±3.87. Mean duration playing experience 27.2 yrs.	Injuries suffered by male & female players in ratio 2.07:1.99 (p=0.130: F=2.31). Overall IR 0.134±0.1/1000 hrs training, male 0.138±0.1, female 0.131±0.08 (p=0.981).
Mauntel 2017 [101]; 16, 57% Moderate	High ankle sprain in American Football, wrestling, baseball; women's volleyball, field hockey, gymnastics, & softball; & men's & women's ice hockey, football, basketball, lacrosse, indoor track & field, outdoor track & field, cross-country, swimming &	No information reported.	Overall high ankle sprain IIR 1.00/10,000 AEs. Higher IIR during competitions than practice (p<0.05). Similar trends were observed between competitions & practices for males (comp 1.78, practice 0.35) & females (comp 1.02, practice 0.19) in sex comparable sports. Sig. sex diff. for; overall IIR male 0.64/10,000Aes vs female 0.36, competition IIR male 1.78 vs female 1.02, practice IIR male 0.35 vs female 0.19. Sport-specific sex diff.; ice hockey competition IIR male 3.36/10,000AE vs female 1.27; basketball practice IIR male 0.68/10,000AE vs female 0.11. In sex-comparable sports; overall male RR, 1.77; (95%CI, 1.28-2.44) competition male RR, 1.75 (95%CI, 1.15-2.68) practice male RR, 1.87 (95%CI, 1.13-3.09). Sport-specific sex diff. male ice hockey competitions (RR, 2.64; 95%CI, 1.03-6.78, male basketball practice RR, 6.20 (95%CI, 1.42-27.12).

	diving, tennis, cross country.		
Melvin 2018 [102]; 16, 57% Moderate	Acute & overuse upper extremity injuries in Ice hockey.	No demographic information reported. Div II&III, 684 male injuries (79%) & 185 female injuries (21%).	Sig. sex diff. for overall IR; male 235.97/10,000AE's, female 124.61 ($p<0.05$), competition IR; male 733.23, female 303.33 ($p<0.05$). Preseason IR; male 149.09, female 52.67 ($p<05$), In season IR; male 256.94, female 142.96 ($p<0.05$), Postseason IR; male 142.73, female 49.01 ($p<0.05$). Overall male RR; 1.89 (CI 1.67-2.15). Preseason male RR; 2.83 (CI 1.69-4.74), In season male RR; 1.80 (CI 1.57-2.05), Postseason male RR; 2.91 (CI 1.33-6.38). No sig. diff. by player position, upper extremity region injured or injury type. Mechanism of injury: contact with player, male IPR; 1.54 (CI 1.24-1.90), contact with playing surface, male IPR; 1.54 (CI 1.24-1.90). Div II male overall IR 167.69/100,000AE (95%CI 135.31-200.08), competition IR 540.85 (95%CI 420.82-660.88) practice IR 53.19 (95%CI 32.34-74.04); female overall IR 148.23/100,000AE (95%CI 100.47-195.99), competition IR 316.80 (95%CI 181.30-452.30), practice IR 87.28 (95%CI 44.51-130.04). Div III male overall IR 260.07/100,000AE (95%CI 238.93-281.22), competition IR 784.38 (95%CI 707.99-860.78), practice IR 102.47 (95%CI 87.33 to 117.60); female overall IR 126.82/100,000AE (95%CI 106.38-147.25), competition IR 296.74 (95%CI 234.38-359.09), practice IR 69.81 (95%CI 52.29-87.32). Div II overall male RR 1.13 (95%CI 0.78-1.65). Div III overall male RR 2.05 (95%CI 1.71-2.46).
Owens 2009 [103]; 16, 57% Moderate	Glenohumeral instability in American Football, wrestling, volleyball, field hockey, gymnastics, ice, hockey, football, basketball, lacrosse, baseball/softball, indoor & outdoor track, cross country, tennis.	17,799 shoulder injuries, 4080 (23%) of which were glenohumeral instability.	Overall GH IIR 0.12/1000AE's. Highest Male sport-Football 0.4/1,000 AE's. Highest female sport 0.18/1,000 AE's. 60% occurred during practice (0.9/1,000 AE's) (comp IR 0.31/1000AE's). Overall Male IIR 0.15/1,000 AE's (95%CI 0.14-0.15, Female IIR 0.06/1000AE's (95%CI 0.05-0.06). No sig. diff in sex comparable sports. Sig. sex diff. in competition football, male-0.17, female 0.09/1,000 AE's. Practice RR 3.5(95%CI 3.29-3.73). Overall male RR 2.67 (95%CI 2.43-2.93). In football competition, male RR 1.99 (95%CI 1.28-3.12).
Post 2022 [151]; 14, 50% Moderate	Overuse injuries in multiple high school sports (2014-19). (12 sports; baseball/softball, basketball, cross-country,	RIO high school injury database. 2014-19. No demographic info reported.	Overall IIR 5.3/10 000AEs (95%CI 5.1-5.7). NTL overuse IIR 3.4/10 000 AEs (95%CI 3.1-3.6), TL overuse IIR 2.0/10 000 AEs (95%CI 1.8-2.2). Overall overuse female IRR 1.9 (95%CI 1.7-2.1). Highest IIR, female cross-country 19.2/10 000 AEs (95%CI 15.0-24.2), female track & field 16.0/10 000 AEs (95%CI 13.5-18.8), female field hockey 15.1/10 000 AEs (95%CI 10.2-21.6). Overuse injury rates were higher for the lower extremity than the upper extremity (IRR 5.7 [95%CI 4.9-6.7]). In male & female sports, most injured anatomical locations - lower leg

	American Football, ice hockey/field hockey, lacrosse, football, swimming, tennis, track & field, volleyball, wrestling, gymnastics).		(male 24.9%, female 31.7%), knee (male 20.5%, female 20.1%); most common diagnoses - medial tibial stress syndrome (male 10.1%, female 18.0%), patellar tendinitis (male 9.1%, female 8.3%).
Rizzone 2017 [104]; 16, 57% Moderate	Stress fractures (lumbar spine, pelvis, lower limb) in all NCAA sports	College age 17-22yrs. Demographic data not included.	Overall IIR5.70/100 000 AEs. Highest IIR; female cross-country 28.59/100 000 AEs, female gymnastics 25.58/100 000 AEs, & female outdoor track 22.26/100 000 AEs. Highest male stress fracture IIR cross-country-16.14/ 100 000 AEs. Sex-comparable sports; female higher overall IIR-9.13/100 000 AEs vs. male 4.44/100 000 AEs; female RR=2.06 (95%CI=1.71, 2.47). Specifically, female basketball 14.04 (vs. 8.29); RR 1.69 (95%CI 1.26, 2.28, cross-country 28.59 (vs. 16.14); RR 1.77 (95%CI 1.05-2.98, football 7.38 (vs. 4.37); RR 1.69 (95%CI 1.09-2.63, indoor track 11.63 (vs. 4.6); RR 2.53 (95%CI 1.18, 5.42), & outdoor track 22.26 (vs. 7.2); RR 3.09 (95%CI 1.765 5.80). Among sex-comparable sports; proportion of stress fractures occurring in the lower back/lumbar spine/pelvis higher in male (23, 12.8%) than female (22, 6.9%). The proportion of stress fractures at the femur higher in female (39, 12.2%) than male (8, 4.4%).
Roos 2017 [105]; 17, 61% Moderate	Acute & overuse injuries in football.	No specific demographic data included. 44 male & 64 female football programmes (104 & 167 team seasons of data, respectively). 1554 male & 2271 female injuries.	No sig. sex difference in overall IIR; male 8.07/1,000 AE's, Female 8.44, Competition IIR; male 17.53 vs female 17.04/1000AE, Practice IIR male 5.47 vs female 5.69/1000AE. 47.2% (733) male injuries & 47.5% (1079) female injuries were non-time loss. Concussion IIR; female 0.59 vs male 0.34/1000AE. Sig. sex diff. IIR; preseason practices, female 10.10 vs male 8.57/1000AE, severe injuries female 9.2% vs male 5.1%. Hip/groin competition male 1.86 vs female 0.84/1000AE, Upper leg male 3.01 vs female 1.98/ 1000AE, hip/groin practice male 0.80 vs female 0.57/1000AE. Head/face in competition female 3.06 vs male 2.19/1000AE. Knee in competition female 3.44 vs male 2.15/ 1000AE. Knee practice female 0.89 vs male 0.70/1000AE. IIR strains in competition male 3.88 vs female 2.58/1000AE. Lacerations in competition male 0.60 vs female 0.28/1000AE. Contusions in practice male 0.68 vs female 0.45/1000AE. Concussion in competition female 1.83 vs male 0.94/1000AE. Overuse IIR practice female 1.31 vs male 1.01/1000AE. cf. with women, men had a higher hip/groin strain rate than women (0.78 vs 0.46/1000AE; RR 1.69 (95%CI 1.33 to 2.14). Overall concussion female 0.59 vs male 0.34/1000AE & knee sprain female 0.66 vs male 0.42/1000AE. Male competition RR 1.03 (95%CI 0.94 to 1.13). Male practice RR 0.96 (95%CI 0.88-1.05). Concussion female RR 1.76 (95%CI 1.32-2.35). Preseason practice female RR 1.18 (95%CI 1.04-1.34). Severe injury female IPR 1.78 (95%CI 1.39-2.28). Hip/groin male RR 2.20 (95%CI 1.56-3.11). Upper leg male RR 1.52 (95%CI 1.19-1.95). Hip/groin practice male RR 1.41 (95%CI 1.09-1.82). Head/face female RR 1.39 (95%CI 1.09-1.78). Knee competition female RR 1.60 (95%CI 1.25-2.05). Knee practice female RR 1.28 (95%CI 1.01 to 1.63). Strain male RR 1.51 (95%CI 1.21 to 1.87). Comp laceration male RR 2.18 (95%CI 1.19-4.00). Practice contusion

			male RR 1.51; (95%CI 1.14 to 2.00). Concussion comp female RR 1.94; (95%CI 1.35 to 2.79). Overuse practice female RR 1.30 (95%CI 1.07 to 1.59). Overall concussion female RR 1.76 (95%CI 1.32 to 2.35). Overall knee sprain female RR 1.59 (95%CI 1.22 to 2.07). Concussions caused by ball contact female RR 2.43 (95%CI 1.37 to 4.33).
Sallis 2000 [267]; 18, 64% Moderate	Acute & overuse injuries.	3767 participants; 18-22 year-old male & female college athletes. Divs. III.	Male athletes; 1018 injuries (54.3%) female athletes; 856 (45.7%). Overall IR, female athletes, 52.5/100 participant-yrs male athletes, 47.7/100 participant-yrs-not statistically sig. Sig. sex diff. in swimming-female 47.08 vs. male 12.37 & water polo-female 18.38 vs. male 7.10 (p<0.001) in pattern of injury. Swimming; back/neck-female 8.19/100partcipant yrs vs. male 1.45, shoulder-female 21.05 vs. male 6.55, hip-female 2.34 vs. male 0.00, knee-female 5.85 vs. male 1.45. Water polo; shoulder-female 8.09 vs. male 3.40. Football; lower leg-female 10.48 vs. male 4.51. Sig. sex diff. overall for hip-female 4.17 vs. male 2.25, lower leg-female 5.39 vs. male 3.61, Shoulder-female 6.92 vs. male 3.09, thigh-female 4.53 vs. male 6.79.
Schroeder, 2022 [152]; 15, 54% Moderate	All injuries in water polo.	NCAA database. 3 male, 4 female teams were observed for 2016-21. 1 male, 1 female team observed 2018-21. 729 injuries included.	No sex diff. in overall IIR, male RR 1.0 (95%CI 0.9-1.2). Sex diff.; weight room injuries male RR 2.6 (95%CI 1.3-5.2), spine/neck injury male RR 2.1 (95%CI 1.2-3.5), muscle spasm/cramp/soreness male RR, 2.3 (95%CI 1.4-4.0), fracture male RR 3.1 (95%CI 1.3-7.7), visceral damage/trauma male RR (3.8; 95%CI 1.3-11.3). Shoulder tendinopathy male RR 3.0 (95%CI 1.3-7.0), lumbar spine muscle spasm/cramps/soreness male RR 3.7 (95%CI 1.4-9.9). Concussion - injury mechanism in males; contact with another player (57.8%), contact with a playing device (28.9%), in females; contact with a playing device (42.1%), contact with another player (23.7%). Offseason practice concussion male RR 3.25 (95%CI 1.2-8.8), concussion via contact with another player male RR 2.9 (95%CI 1.3-6.4).
Simmons 2017 [107]; 17, 61% Moderate	Acute injuries (head, neck, facial) in ice hockey.	No demographic info. included.	Overall IIR sig sex diff.; male 1.75/1,000 AE's vs female 1.16/1000 AE's. Competition IIR; male 5.86 vs female 2.95. Time loss IIR competition male 2.56/1000 AEs vs female 2.21. Time loss IIR practice male 0.28/1000 AEs vs female 0.32. Proportion cervical spine/neck female 25.6% male 11.5%. Most common HFN injury was concussion in both sexes. The proportion of competition HFN injuries that were concussion female 68.2% male 42.5%. Concussion IIR; practice-male 0.25/1,000 AE's vs female 0.30. Competition-male 2.49/1,000 AE's vs female 2.01. No sex analysis done. Overall male RR 1.51 (95%CI 1.25-1.84). Competition male RR; 1.99 (95%CI

			1.58-2.50). Non time-loss injury male IPR 2.37 (95%CI 1.59-3.51). Cervical spine/neck female IPR 2.23 (95%CI 1.05-4.75). Competition female concussion IPR 1.60 (95%CI 1.34-1.93).
Trojan 2019 [108]; 16, 57% Moderate	Knee-patellofemoral pain in all NCAA sports	College age 17-22yrs. Demographic data not included.	Overall IIR; male 14.15/100,000 AEs vs female 19.35/100,000 AEs. Lacrosse practice male RR 0.32 (95%CI 0.13-0.79), football practice male RR 0.53 (95%CI 0.29-0.96). Basketball competition male RR 2.41 (95%CI 1.11-5.24). Football overall male RR 0.51 (95%CI 0.31-0.84). Sex comparable sports; practice male RR 0.70 (95%CI 0.55-0.89), overall male RR 0.77 (95%CI 0.63-0.95). Patellar tendinitis accounted for 100% patellofemoral injuries in women's outdoor track, 85.7% patellofemoral injuries in men's swimming, & 83.3% patellofemoral injuries in men's outdoor track. PFPS was the most prevalent injury in female field hockey, lacrosse & softball, accounting for 50.0%, 29.4% & 29.4% injuries, respectively.
Tummala 2018 [109]; 16, 57% Moderate	Acute & overuse ankle injuries in basketball.	College age 17-22yrs. Demographic data not included. 1,388; (1298 male, 90 female) ankle injuries.	Male IR 1.49 injuries/1000 AEs, female IR 1.21/1000AEs. Male competition IR; 2.51/1000 AEs, Male practice IR; 1.23/ 1000 AEs. Male preseason IR 2.00/ 1000 AEs vs. in-season IR; 1.37/1000 AEs & postseason IR; 0.84/1000 AEs. Female IR 1.21 injuries/1000 AEs. Female competition IR; 2.00/1000 AEs vs. practice IR; 0.98/1000 AEs. Female preseason IR; 1.45/1000 AEs vs. in-season IR; 1.18/1000 AEs & postseason IR; 0.45/1000 AEs. Females have a sig. lower rate of ankle injuries overall; IPR 0.81 (95%CI, 0.75-0.88). Female were sig. more likely to be injured during season; IPR 1.08 (95%CI 1.02-1.14) & less likely to be injured during preseason; IPR, 0.87 (95%CI 0.77-0.99). Female sig. greater acute noncontact mechanisms; IPR 1.20 (95%CI 1.06-1.35), less often because of contact; IPR 0.88 (95%CI 0.81-0.95). Female sig. more likely to have a recurrent injury; IPR 1.77 (95%CI 1.22-2.57). Male injuries 37.3% resulted in a time loss of less than 7 days & 56.7% lasted longer than 7 days. Female injuries 67.2% resulted in a time loss of less than 7 days & 29.0% lasted longer than 7 days. Female IIR lower but a greater proportion of female injuries are at the ankle.
Zuckerman 2015 [112]; 18, 64% Moderate	Concussion in American Football, wrestling, baseball; women's volleyball, field hockey, gymnastics, & softball; & men's & women's ice hockey, football, basketball, lacrosse, indoor track & field, outdoor track & field, cross-country,	No Demographic info included. NCAA athletes. 2009-14	Overall concussion IIR 4.47/10,000 AE. Overall competition IIR 12.81/10,000 AEs & practice IIR 2.57/10,000 AEs. Highest IIR wrestling 10.92/10,000 AEs. Sig. sex diff. in; Basketball overall IIR f 5.95/10,000AE vs. m 3.89 & competition IIR f 10.92 vs. m 5.6; Female basketball overall RR=1.53; (95%CI, 1.16-2.03) & competition RR=1.95; (95%CI, 1.21-3.13). Football overall IIR f 6.31 vs. m 3.44 & competitions IIR f 19.38 vs. m 9.69; Football overall female RR=1.83; (95%CI, 1.34-2.51) & competition female RR=2.00; (95%CI, 1.35-2.96). Lacrosse overall IIR f 5.21 vs. m 3.18; Lacrosse overall female RR 1.64 (95%CI 1.12 2.40). Softball overall IIR f 3.28 vs. m 0.90, & competition IIR f 5.61 vs. m 1.20 & practice IIR f 1.75 vs. m 0.72; Softball overall female RR=3.65; (95%CI, 2.09-6.39, competitions female RR 4.66 (95%CI 2.17-10.03), & practice female RR 2.44 (95%CI 1.05-5.65).

	swimming & diving, tennis, cross country.		
Zupon 2018 [113]; 15, 54% Moderate	Back, neck & spine injuries in ice hockey.	College age 17-22yrs. Demographic data not included. Men's ice hockey data: 27 Division III programmes provided 60 team-seasons. Women's ice hockey data; 16 Division III programmes provided 36 team seasons. No division II institutions included due to playing in a different league.	Male competition IR 1.49 (95%CI 1.10–1.89), practice IR 0.46 (95%CI 0.33–0.58), overall IR 0.47 0.71 (95%CI 0.58–0.85). Female competition IR 1.50 (95%CI 0.96–2.05), practice IR 0.71 (95%CI 0.48–0.93), overall IR 0.92 (95%CI 0.70–1.14). No sig. sex diff. in proportion of NTL injuries, severe, recurrent, or required surgery injuries. Overall male IRR 0.85 (95%CI 0.67-1.08), competition male IRR 1.13 (95%CI 0.81-1.59), practice male IRR 0.67 (95%CI 0.48-0.94). No sig. sex diff. in proportion of NTL injuries (IPR 1.08 95%CI 0.90-1.30), severe (IPR 1.93 95%CI 0.43-8.77), recurrent injuries (IPR 1.02 95%CI 0.60-1.74) or injuries that required surgery (IPR 0.86 95%CI 0.08-9.36).
ADOLESCENT			
Baugh 2016 [114]; 15, 54% Moderate	Acute & overuse injuries in Rowing	Demographic info not included. High school age. The number of programs providing data varied by sport & year. 2011-2012 through 2013-2014 academic yrs. Eight boys' rowing programs provided 13 team-seasons of data. Eleven girls' rowing programs provided 17 team-seasons of data.	Boys' & girls' rowing IR of 2.39/1000 AEs (95%CI 1.78-3.00) & 8.60/1000 AEs (95%CI 7.38-9.82). No diff. existed in injury distributions by body part or diagnosis in boys' & girls' rowing. Overall rate in girls was 3.60 times that of boys (95%CI 2.69-4.82). Competition rates were higher than practice rates in boys (RR 2.01 95%CI 1.12-3.62) but not in girls (RR 1.06 95%CI 0.72-1.56).

Belilos 2023 [139]; 17, 61% Moderate	Acute & overuse injuries in swimming & diving. RIO database 2008-19	High school athletes. No further demographic information included.	Overall IIR 2008-19 across swimming & diving a 0.26/1000 AEs, (95%CI 0.24- 0.28), male 0.20/1000 AE, female 0.31/1000 AE. IIR higher in practice than competition (P=0.051). Overall female RR 1.57 (95%CI 1.32-1.86; p<0.05), practice female RR 1.53 (95%CI 1.27- 1.85; p<0.05), competition female RR 1.81 (95%CI 1.15- 2.84; p<0.05). There were no sig. diff. in the proportion of injuries among classes (freshmen 23.1%, sophomores 27.2%, juniors 26.6%, & seniors 23.1%). The shoulder was the most commonly injured anatomic location in males (43.0%) & females (39.9%). There was no sig. diff. between overuse injuries in males (48.5%) & females (48.2%). In diving, injury to the head accounted for 47% injuries in males & 29% in females. A greater proportion of injuries in females were to the knee (16.7%) than in males (5.9%).
Beis 2007 [266]; 20, 71% Moderate	Acute & overuse injuries in Taekwondo	2739 young & adult males & females participating in the national championships of Hellenic Federation of Taekwondo. The adult men & women were age >18yrs, junior boys & girls were 14-17yrs, boys & girls, 11-13 yrs.	No sig. sex diff. Overall IR female 11.36/1,000 A-E, male 7.40/1,000 AE's or for age groups; Adult (age> 18yrs) male 6.85/1,000 AE's, female 2.43, junior (age 14-17yrs) male 8.97/1,000 AE's, female 17.01, child (age 11-13 yrs) male 6.16/1,000 AE's, female 9.37. Across age groups no sig. sex diff. adult male OR 2.861 (95%CI 0.350-23.395, Junior boys OR 0.532 (95%CI 0.207-1.362). Child boys OR 0.668 (95%CI 0.256-1.745). Overall male OR 0.703 (95%CI 0.383-1.293). No sig. sex diff. across mechanism of injury or body part.
Borowski 2008 [197]; 17, 61% Moderate	Acute & overuse injuries in Basketball	No demographic info included. High school sports in the USA	Overall IR; 1.94/1,000 AE's. IR greater (p<0.05) during competition (3.27) practice (1.40). IR was sig. (p<0.05) greater among girls (2.08) than among boys (1.83). IR greater during competition than practice RR 2.33 (95%CI 2.10-2.57). IR was sig. greater among girls RR 1.14 (95%CI1.03-1.26). Female basketball players sustained a greater proportion of concussions (IPR 2.41 95%CI 1.49-3.91) & knee injuries (IPR 1.71 95%CI 1.27-2.30). Boys more frequently sustained fractures (IPR 1.87 95%CI 1.27-2.77) & contusions (IPR 1.52 95%CI 1.00-2.31). The ankle/foot (39.7%), knee (14.7%), head/face/neck (13.6%), arm/hand (9.6%), & hip/thigh/upper leg (8.4%) were most commonly injured. Most frequent injury diagnoses were ligament sprains (44.0%) muscle/tendon strains (17.7%), contusions (8.6%), fractures (8.5%), & concussions (7.0%).
Bretzin 2018 [196]; 18, 64% Moderate	Concussion in Male sports included basketball, baseball, American Football, ice hockey, lacrosse, football, swimming & diving & wrestling. Female sports included basketball, competitive cheer, lacrosse, football, softball,	No specific demographic info. In the 2015-2016 school year, there were a total of 755 Michigan high schools (i.e., 9th-12th grades) that participated in this study.	Overall clinical incidence for all sports was 1.7/100 player-seasons (95%CI=1.6-1.8); 1.9 (95%CI=1.8-2.0) for male sports & 1.5 (95%CI=1.4-1.6) for female sports. Female athletes were at a 1.9 (95%CI 1.8-2.2) times greater risk for enduring SRCs than male athletes in sex-comparable sports, with a greater risk in baseball/softball (RR 2.7 [95%CI=1.9-3.8]), basketball (RR 2.5 [95%CI 2.1-2.9]) & football (RR 1.6 [95%CI 1.4-1.9]). Female student-athletes had sig. (p<0.001) longer time loss (days) than male student-athletes (13.8±12.9 vs. 12.0±12.1). Sig. sex diff. in RTP (days) in Basketball (p=0.024); Male 12.7±10.5 Female 15.1±13.5. Mean number of missed school days did not differ between sexes (p=0.70).

	swimming/diving & volleyball.		
Bretzin 2021 [140]; 18, 64% Moderate	Concussion in football	n= 43,741 male & 39,637 female soccer players (2016-19).	1507 football related SRCs (37.0% male). A greater proportion of female athletes than male athletes were in lower grades in school 9th grade; female 308 (32.4%), male 117 (21.0%) (p<0.001), junior varsity soccer; female 337 (35.5%) male 141 (27.1%) (P =0.004) or had a prior history of concussion; female 199 (21.0%), male 78 (14.0%) (p<0.001). Most documented SRC occurred during competition in both male (813 [85.5%]) & female (476 [85.6%]) athletes (p=0.55). Overall IIR 1.8 (95%CI 1.72-1.90)/100 athletes per season. Female RR 1.88 (95%CI 1.69-2.09; p <0.001).
Changstrom 2015 [115]; 19, 68% Moderate	Overuse Injuries-stress fractures in American Football, boys' & girls' football, volleyball, basketball, wrestling, baseball & softball, lacrosse, track & field, swimming & diving, cross country, girls' field hockey, girls' gymnastics, boys' ice hockey, girls cheerleading.	Age 15.8 (±13-19) yrs (median age 16 yrs), BMI, 22.7(±15.6-41.5) (female-21.3 & male-24.0).	Overall IR 1.54/100,000 AE's. Sig. sex diff. (p<0.05) between overall in sex comparable sports; female 2.22/100,000 AE's, male 1.27/100,000 AE's. Track & field; female, 4.76, male 1.79 (p<0.05) & basketball female, 2.71, male 1.05 (p<0.05). No sig. diff. for lacrosse female 2.8 male 1.5, cross country female 10.62, male 5.42, football female 2.3, male 1.69 or baseball/softball female 0.23, male 0.75. Sex comparable sports; Female RR, 1.75 (95%CI 1.38-2.23). Track & field Female RR 2.66 (95%CI, 1.63-4.36), Basketball Female; RR 2.58 (95%CI 1.59-4.20). No sig. diff. for Lacrosse Female RR; 2.54 (95%CI 0.94-6.86), Cross country female RR 1.96 (95%CI 0.77-4.98), football female RR 1.36 (95%CI 0.84-2.19) or baseball/softball female RR 0.31 (95%CI 0.09-1.10). Rate ratios for volleyball & swimming & diving could not be calculated because no stress fractures were reported for boys' volleyball & girls' swimming & diving.
Cierna 2017 [41]; 19, 68% Moderate	Acute & overuse injuries (competition only) in Karate	246; 160 male, 86 female. Age 12-17 yrs.	Overall IIR-AE 45.2/1000AE (95%CI 38.78-52.58, IIR-ME 35.88/1,000ME (95%CI 30.70-41.68). Injury Proportion/100athletes (IP) 9.87 (95%CI 8.44-11.46). No sig. sex diff. in overall IP, IIR-AE or IIR-ME. Overall girls RR-AE 1.71 (95%CI 1.01-2.91), Overall girls RR-ME 1.69 (95%CI 1.00-2.86). Most frequently injured site; Male Head/neck (66%) & lower limb (21%), female Head/neck (56%) & trunk & lower limb (12% each). Most common injury type; male-contusion (79%) & fracture (4%), female-contusion (84%) & epistaxis (15%).
Cierna 2018 [265]; 18, 64% Moderate	Acute & overuse injuries in Karate	Junior (age 16-18yrs) 948 male, 604 female. U21, 738 male, 522 female. Total, 1,686 male, 1,126 female.	Sig. sex diff. for overall IR-male=10.74/100 athletes, female 6.75, IIR male 48.69/1,000 AE's, female 30.28 & male 20.06/1,000ME's, female 14.12. Overall IIR female RR 0.6 (95%CI 0.5-0.8) (AE, female RR 0.7 (95%CI 0.5-0.9) (ME).

Collins 2008 [116]; 18, 64% Moderate	Acute & overuse injuries in Rugby Union	n=594, age 16.5±1.2yrs, height 175.26±8.64cm, weight 76.77±14.36kg. 517 males age 16.5±1.2yrs, height 176.53±8.13cm, weight 78.62±13.59. 77 females, age 16.3±1.2yrs, height 165.61±6.86cm, weight 62.19±11.88kg.	Total 594 injuries (103 practice, 488 competition, 3 unspecified). Overall IIR 5.2/1000 total AE. Sig. sex diff.; male 5.5/1000 total AE, female 4.1/1000AE. Practice IIR 1.3/1000AE (male 1.3 vs. female 1.0; not sig., match IIR 15.2/1000AE, (sig sex diff; male 14.8 vs. female 19.5). Overall injury male RR1.3 (95%CI 1.1-1.7; p=0.02). Practice (vs. match) RR 12.1 (95%CI 9.8-14.9; P.001). Match injury female RR 1.3; (95%CI 1.0-1.7; p=0.048). Male time loss RR1.5 (95%CI 1.1-2.0; p=0.005). Overall, most commonly injured body sites were head (21.7%, ankle (13.3%, shoulder (12.8%) & knee (11.1%); most common diagnoses-fractures (16.0%, concussions (15.8%) & ligament sprains (incomplete tears) (15.7%). 87.0% injuries were in male athletes. Patterns of injury; head (male 22.1%, female 19.5%, ankle (male 13.2%, female 14.3%, shoulder (male 13.2%, female 10.4%) & knee (male 10.6%, female 14.3%). Male time-loss injuries (>10 days) 52.3% (vs. female 35.1%). All career ending injuries were in male athletes (11) 4 fractures, 2 complete dislocations, 2 nerve injuries, 1 concussion, 1 torn cartilage & 1 unknown shoulder injury. Injuries were most commonly a new injury (86.4%) rather than a recurrence or complication of a previous injury.
Darrow 2009 [172]; 18, 64% Moderate	Acute & chronic injuries (severe time loss injuries) in Football, Basketball, Volleyball, Wrestling, Baseball/softball	1378 severe injuries. No demographic info. High school age in USA	Overall, 0.39 severe injuries/1000AE's. Football had highest IR (0.69, wrestling (0.52, girls' basketball (0.34) & girls' football (0.33). Sig. sex diff. overall (0.45 male, female (0.26). Sex comparable sports sig. sex diff.; female 0.29/1,000 AE's vs. male 0.23. More specifically, female basketball (0.34) male basketball (0.24) (RR,1.43 95%CI 1.10-1.86; p=0.009). The severe injury rate sig. greater in competition (0.79) than practice (0.24). Overall Male RR 1.74 (95%CI 1.54-1.98; p<0.001). Sex comparable sports, female RR 1.28 (95%CI 1.08-1.52; p=0.006). Female Basketball RR 1.43 (95%CI 1.10-1.86; p=0.009). Overall competition RR 3.30 (95%CI 2.97-3.67; p<0.001). Female football knee IPR 2.14 95%CI 1.30-3.53; p=0.001). Male football fracture IPR 1.90 95%CI 1.11 3.26; p=0.016). Female football ligament sprains (complete tear) IPR 2.88 95%CI 1.26-6.57; p=0.005). Female basketball IPR 2.17 (95%CI 1.38-3.41; p<0.001). Male basketball foot/toe injuries; IPR 5.33 (95%CI 1.22-23.35 p=0.012). Male basketball fracture IPR 2.49 (95%CI 1.59-3.91; p<0.001). Female basketball IPR 1.95 (95%CI, 1.88-2.02; p<0.001).
Fernandez 2007 [173]; 17, 61% Moderate	Acute lower extremity injury in Baseball, American Football & wrestling; Softball & volleyball; boys' & girls' basketball & football	No demographic info included. High school sports in the USA	LESRI rate 1.33/1,000 AEs across all sports. Highest male IR; 2.01/1,000 in football & Highest female IR; 1.59/1,000 in football. Female with ligamentous knee injuries were 2 times more likely to require surgery than males (67% vs. 35%; p<0.01). Female had 1.5 times proportion of season-ending LESRIs of males (12.5% vs. 8%; p<0.01). Among high school athletes in 2005, 2,298 of 4,350 injuries (52.8%) were LESRIs. IPR for surgery in football 3.57 (95%CI=1.20 to 10.61) times higher in Female players (7.3% vs. 2.0%); p=0.014. IPR of female surgeries for ligamentous tears of knee (e.g., anterior cruciate ligament [ACL] tears) were 1.90 (95%CI 1.24 to 2.93) higher (67.4% vs. 35.4%) p=0.005. Overall, season ending LESRI 1.55 (95%CI 1.12 to 2.15) more likely in females. (12.5% vs. 8%) p=0.008.

Hinton 2005 [136]; 16, 57% Moderate	Acute & overuse injuries in Lacrosse	2259 male & 1141 female participants. Most participants were upper-level high school players aged 15 to 18 yrs who aspired to play collegiate lacrosse. No specific demographic info reported	Sig. sex diff. in overall IR; male 2.89/1,000 AEs, female 2.54/1,000 AE's, Ankle IR; male 0.47/1,000 AE's, female 0.64, neck IR; male 0.08, female 0.02, shoulder IR; male 0.24, female 0.10, upper leg IR; male 0.22, female 0.10, back/trunk IR; male 0.22, female 0.10, concussion IR; male 0.29, female 0.10. Overuse IR male 0.24, female 0.36 *Not sig. Overall male IRR 1.14 (95%CI 1.00-1.30). Game male IRR 3.00 (95%CI 2.26-4.05). Ankle injury male IRR 0.73 (95%CI 0.55-0.98), neck injury male IRR 3.89 (95%CI 1.13-20.73), shoulder injury male IRR 2.38 (95%CI 1.32-4.55), upper leg injury IRR 2.15 (95%CI 1.18-4.14), back/trunk injury male IRR 2.11 (95%CI 1.15-4.06), concussion male IRR 2.99 95%CI (1.65-5.79), overuse injuries male IRR 0.69 (95%CI 0.46-1.03).
Huffman 2008 [118]; 15, 54% Moderate	Rare injuries & conditions in American Football, Football, Volleyball, Baseball/softball, Basketball, Wrestling	Demographic info not included. High school age. 2005-07 data analysed	Overall, RIC IRs were higher among boys (12.4/100,000AE's) than girls (2.51/100,000AE's) & higher in competition (15.9) than in practice (6.32). Eye injuries IR of 1.10/100 000 AEs. IRs higher in boys (1.27) than girls (0.75) not sig. Neck & cervical IRs were higher in boys (7.99) than girls (0.92). Dehydration & heat illness IRs were higher in boys (2.34) than girls (0.42). Overall, RIC-RR 4.93 (95%CI 3.39-7.18) & higher in competition than in practice (6.32) RR 2.52 (95%CI 2.02-3.14). Eye injuries RR 1.69 (95%CI 0.80-3.57) not sig. Neck & cervical-RR 8.69 (95%CI 4.73-15.96). Dehydration & heat illness RR 5.59 (95%CI 2.24-13.97).
Jayanthi 2020 [80]; 19, 68% Moderate	Injuries associated with sport specialisation - multiple sports	n=1208 participants at baseline. Final study sample n=579 participants. By 18-month follow-up survey n=308 (53%) participants remained in the study. By 3-year follow up study n=61 (11%) completed the sports participation. Mean age at baseline 14.05±2.26 yrs, injured participants 14.41±2.08 yrs, uninjured participants 13.03±2.46 yrs (p<.001). (more detailed characteristics included in the paper).	Univariate analysis; female OR 1.28 (95%CI 1.01-1.62; P=.04). (increasing chronological age OR, 1.11 (95%CI 1.05-1.17); p<.001, higher BMI OR 1.04 [95%CI 1.12-1.27]; P=.05, increased wkly hrs of physical activity OR 1.19 per 5 h/wk (95%CI 1.02-1.05; p <.001) & organized sports OR 1.39 per 5 h/wk (95%CI 1.27-1.52; p<.001). Highly specialized (cf. to low specialised) athletes OR 1.72 (95%CI 1.35-2.20) & 1.52 times greater odds of an injury than moderately specialized athletes (95%CI 1.18-1.96). Highly specialized athletes RR 1.41 (95%CI 1.06-1.87; p=.02) (after adjusting for sex, age, time from baseline, BMI, & wkly hrs in organized sports). Overuse injuries Female OR 1.50 (95%CI, 1.14-1.99; P =.004). Multivariate analysis for overuse injuries consisted of the following variables: sex, time, BMI, total wkly hrs of physical activity, wkly sports hrs, exceeding the wkly hrs of organized sports by the age recommendation, & degree of sport specialization. Female OR 1.43 (95%CI 1.05-1.96; p=.02) cf. to males. After controlling for all variables, athletes categorized as highly specialized had 1.46 (95%CI 1.04-2.04) times greater odds of an overuse injury than low specialized athletes (P=.03).
Kerr 2011 [175]; 16, 57% Moderate	Acute Injuries (contact) in American Football, , Volleyball, Basketball, Wrestling, Baseball/Softball	9010 player-player contact injuries. (46% all injuries).	Overall IIR-11.6/10 000 AEs (practice rate=6.2/10 000 AEs, competition rate=26.1/10 000 AEs). In football; A larger proportion of females had knee injuries (25.1%) than males (16.9%; p=0.003). In Basketball; player-player contact injuries represented a greater portion of total injuries among males (45.7%) than females (35.3%; p<0.001). A larger proportion of females had knee injuries (14.1%) than males (7.5%; p=0.002), a larger proportion of females had concussions (17.5%) than

			males (6.9%; p<0.001). In football; female knee IPR 1.48 (95%CI 1.14-1.93). In Basketball; male player-player contact IPR 1.29 (95%CI 1.16-1.44), female knee IPR 1.87 (95%CI 1.24-2.83, female concussion IPR 2.53 (95%CI 1.71-3.74).
Kerr 2011 [176]; 19, 68% Moderate	Acute injury-Dislocation/separation injuries in American Football, football, wrestling, baseball/softball, basketball, volleyball	No demographic info included. High school age 14-18yrs. 2005-09	Overall males sig. higher IR (1.30/10,000AE's) vs. female (0.33). In gender-comparable sports, no sig. sex diff. (m 0.39 vs. f 0.34; p=0.406). Football, no sig. sex diff. Male overall RR 3.91 (95%CI 3.12-4.89; p=0.001). Driven by wrestling & football. Football male IPR 2.09 (95%CI 1.09-4.01; p=0.024). Only 2% injuries, male shoulder dislocations/separations IPR 3.23 (95%CI 1.04-10.00; p=0.021).
Kerr 2017 [66]; 16, 57% Moderate	Concussion in Football , basketball, softball/baseball, American Football, Track, wrestling, cheerleading, volleyball	No Demographic info included. Middle school age.	57 game & practice concussions across 76,384 AEs; IR 0.75/1,000 AEs. American Football (2.61/1,000 AEs) & female football (1.30) had highest concussion rate. Sex-comparable sports overall sig. sex diff.; female 0.66 vs male 0.18/1,000 AE's. Findings were retained in sport-specific analyses, but only found sig. in football. Female football IR 1.30 vs. male football 0.15/1,000 AE's. Overall concussion rate higher in games than practices (1.15 vs 0.63/1,000 AEs). This finding was retained per sport, although only girls' basketball reported a sig. finding. In games, female basketball had higher concussion rate than female football (2.61 vs. 2.47/1,000 AE's). Game IRR 1.83 (95%CI 1.06-3.15). Sex-comparable sports; female IRR3.73 (95%CI 1.24, 11.23). Female football IRR 8.46 (95%CI 1.04-68.77). Overall games IRR 1.83 (95%CI 1.06-3.15).
[177]; 20, 71% Moderate	Acute & overuse injuries in Lacrosse	1498; 1098 male, 408 female. Age divisions U9-U15. No specific demographic info included.	Sig. sex diff. for overall IIR; male 12.7/1000AE (95%CI 11.1-14.3) game/practice, female 8.7(95%CI 6.5-10.9) & in game IIR; male 30.2/1000AE (95%CI 25.3-35.1, female 17.1(95%CI 11.1-23.1) & time-loss IIR in game male 4.5/1000AE (95%CI 2.6-6.4, female 3.3(95%CI 0.7-6.0). No sig. sex diff. in practice IIR; male 6.6/1000AE (95%CI 5.2-7.9, female 5.6 (95%CI 3.5-7.7). Overall male RR; 1.5 (95%CI 1.1-1.9), Game male RR 1.8 (95%CI 1.2-2.6). Trunk IPR male IPR 4.2 (95%CI 1.0-16.8). Head female IPR; 2.3 (95%CI 1.2-4.5). Highest proportion of body parts injured; male knee (14.5%), trunk (14.1%)*, ankle (9.5%), female head/neck (20.3%)*, ankle (15.3%, hand/wrist (10.2%). *=sig sex diff. No sig. for diagnoses-contusion & sprain similar in both.
Kolstrup 2016 [67]; 20, 71% Moderate	Acute & overuse injuries in football	45,606 children & adolescents played, (71% boys & 29% girls). 1831 injured players (60% male & 40% female). Mean age injured male was 15.1 (1.8) yrs, mean age injured female 14.7 (1.5) yrs, p<0.001.	Overall IR 15.3 (14.6;16.0)/1,000 player hrs. Overall sig. sex diff.; female 20.3 (18.9;21.8)/1000 player hrs vs. male 13.1 (12.3;13.9) p<0.001. IR ankle & foot injuries in higher in female 7.02, than male 3.75 p<0.001. IR of knee & lower leg higher in female 4.30 than male 2.30 p<0.001. *diff. augmented in 11-15 year olds. When comparing genders only in the 11-15-year olds, all incidences were highest among girls. Conversely, in the group of 16-19-year olds, all sig. gender diff. reveal a higher incidence in the group of boys. Female RR 1.5 (p<0.001). Female higher proportion of injuries to knee/lower leg-23.8%, (vs. male-19.0%, p<0.01). Male higher proportion of fracture-6.8%, (3.3% female, p<0.001). Male; higher proportion hip & thigh injuries, 14.6% (12.4;16.9, than

		Players from Europe (89%), North America (4%, Asia (3%, Africa (2%) & South America (2%).	girls, 7.4% (5.5;9.7, p<0.001). *Youngest females have higher IR than any other group. *IR decreased with age.
Lincon 2011 [119]; 17, 61% Moderate	Concussion in Football, basketball, lacrosse, softball, baseball, American Football, wrestling, field hockey, cheerleading.	No demographic info included. High school sports in the USA	Girls had sig. higher rate (per 1,000 AE's) of concussion in sex comparable sports. Basketball IR-f 0.16, m 0.10; Football IR-f 0.35, m 0.17; Softball/baseball IR f 0.11, m 0.06. Basketball RR 1.7 (95%CI 1.3-2.2), Football RR 2.1 (95%CI 1.6-2.6) & Softball/baseball 1.9 (95%CI 1.2-3.0).
Maciejewski 2016 [44]; 19, 68% Moderate	Acute & overuse injuries in Judo	4 major divisions: 76 junior men (17.67±1.08 yrs), 52 junior women (17.64±1.13 yrs), 52 boys (11.97±2.40 yrs), 12 girls (11.88±2.60 yrs).	No sig. sex diff. in IR. Boys 84.03 (47.20-120.86, girls 37.03 (14.29-88.37). Jnr male 106.56 (73.11-140.00), Jnr female 112. 40 (71.49-153.31). Sig. sex diff. for upper body IR Jnr men 54.64 (30.70-78.59) Jnr female 42.64 (17.44-67.83). Boys OR 3.13 (95%CI 0.62-15.76). Jnr female OR 1.20 (95%CI 0.59-2.43). Upper body injury Jnr male OR 4.17 (95%CI 1.57-11.08).
Marar 2012 [120]; 18, 64% Moderate	Concussion in Baseball/softball, Basketball, Cross-country & track & field, American Football, Gymnastics, Swimming & diving, Wrestling, Hockey, Football, Volleyball, Lacrosse	No demographic info included. High school sports in the USA	Overall injury rate of 2.5 per 10,000 AEs. The injury rate sig. higher in competition (6.4) than practice (1.1). Football had highest concussion rate (6.4, followed by boys' ice hockey (5.4) & boys' lacrosse (4.0). In sex comparable sports, girls had sig. higher concussion rate (1.7) than boys (1.0). In football girls had sig. higher IR (3.4/10,000 AEs) than boys (1.9). Basketball girls had sig. higher rate of concussion (2.1) than boys (1.6). Softball players had sig. higher rate of concussion (1.6) than baseball players (0.5). Overall competition to practice RR 5.7 (95%CI 5.2-6.3). Concussions represented a greater proportion of total injuries among boys' ice hockey (22.2%) than all other sports studied (13.0%) (injury proportion ratio [IPR], 1.7 (95%CI, 1.4-2.1; p<0.01). In sex comparable sports; girls to boys RR 1.7 (95%CI 1.4-2.0). In football girls to boys RR 1.8 (95%CI 1.4-2.3) & concussions represented a greater proportion of total injuries among girls (15.4%) than boys (11.1%); IPR 1.4 (95%CI=0.96-2.0; p=0.08). Basketball girls to boys RR 1.3 (95%CI 1.03-1.8; p<0.03). Softball players to baseball RR 3.2 (95%CI 2.1-5.4; p<0.001). Concussions represented a sig. greater proportion of total injuries among softball players (13.4%) than baseball players (5.4%) (IPR 2.5 95%CI 1.6-3.9; p=<0.001). Majority of concussions resulted from participation in football (47.1%, 912, followed by girls' football (8.2%, 159, boys' wrestling (5.8%, 112, & girls' basketball (5.5%, 107). In more than 40% athletes in sports other than girls' swimming & girls' track, concussion symptoms resolved in 3 days or less. Athletes most commonly returned to play in 1 to 3 wks (55.3%, with 22.8% returning in less than 1 wk & 2.0%

			returning in less than 1 day. In basketball; boys had quicker symptom resolution times & return-to-play outcomes than girls; however, neither diff. was sig.
Marshall 2020 [150]; 16, 57% Moderate	All injuries in cross country (high school).	N=681 patient cases (415 females, age 15.2±1.2 yrs, 266 males, age 15.4 2±1.3 yrs). The number of exposed clinical practice sites (i.e., high schools with student-athletes participating in cross-country & at risk for injury) was not different between sexes for each academic year (female 19.2±14.9, male 18.0±14.0; p=.86). 2009-19.	No sex diff. in injury type by anatomical location or diagnosis. There was a trend towards a greater proportion of female injuries being to the ankle & hip & a diagnosis of tendinopathy.
Messina 1999 [180]; 17, 61% Moderate	Acute & overuse injuries in Basketball	973 male athletes. 890 female athletes. 75 of the 100 boy's schools completed the study, 80 of the 100 girls' schools completed the study with an additional. The average number of players per team was 13 for the boys & 11 for the girls. The average number of games per	Overall Male IR 0.56/athlete/season. Female IR 0.49/athlete/season (p<0.0015). Overall Male IR 3.2/1,000 plyr hrs, Female IR 3.6 (not sig.). Practice Male IR 1.8/1,000 plyr hrs, Female IR 2.0 (p<0.09). No sig. diff. for type of injury. Lower extremity IR higher in females (p<0.003, knee IR females 0.1/athlete/year, male 0.06 (p<0.0001). Face IR higher in males (p<0.023). Rate of severe injury; male 0.027/athlete/year, female 0.038 (not sig.). Based on exposure time, risk of knee injury was 2.3 times greater in female athletes than in male athletes (p<0.001).

		season was 31 for the boys' teams & 29 for the girls' teams. The average number of practices per season was 77 for the boys' teams & 67 for the girls' teams.	
Mitchell 2015 [122]; 16, 57% Moderate	Knee-Patello-femoral instability injury (PFII) in American Football, Football, Volleyball, Basketball, track & field, Baseball/softball, field hockey, gymnastics, Lacrosse, Ice Hockey, swimming & diving, cross country	No demographic info reported. High school sport	Overall IR 1.95/100,000 AEs. Highest rates; girls' gymnastics (6.19/100,000 AEs, boys' football (4.10). Overall IR; female 1.66, male 2.15. In sex-comparable sports females; 1.47, males 0.88. Football IR female 2.92, male 1.22 ($p<0.05$). Overall female RR 0.77; (95%CI, 0.62-0.94). In sex comparable sports; female RR 1.67 (95%CI 1.19-2.34). Football female RR 2.40 (95%CI 1.39-4.24). Sex-comparable sports showed similar proportions of PFIs relative to total knee injuries overall. PFIs accounted for a larger proportion of total knee injuries in baseball (12.6%) vs girls' softball (4.8%); IPR, 2.63 (95%CI 1.06-6.55). Contact injuries male IPR 1.53 (95%CI 1.24-1.88). Player-player contact, male IPR 2.45 (95%CI, 1.70-3.55). Non-contact injuries female, IPR 1.56 (95%CI, 1.23-1.98).
Mitchell 2016 [121]; 16, 57% Moderate	Acute knee Injuries in American Football, Football, Volleyball, Basketball, track & field, Baseball/softball, field hockey, gymnastics, Lacrosse, Ice Hockey, swimming & diving, cross country, cheerleading.	No demographic info reported. High school sport	Overall IR 5.1/100,000 AE's. Overall IR; males 5.9, females 4.4 ($p<0.05$). Sex comparable sports overall IR; female 5.5, male 2.5 ($p<0.05$). Overall male, RR 1.4 (95%CI 1.2-1.5). Sex comparable sports overall female RR 2.2 (95%CI 1.8-2.7). Player-player contact male IPR 1.7 (95%CI 1.4-2.1). Non-contact mechanisms female IPR 1.4 (95%CI 1.2-1.6).

Miyake 2016 [181]; 19, 68% Moderate	Acute & overuse injuries in Badminton	133 (94 male, 39 female) badminton players in junior high school (18 male, age 13.4±0.7yrs, height 161.7±7.9cm, weight 49.5±7.6kg; 16 females, 13.8±0.8yrs, 159.4±6.1cm, 49.9±6.8kg), high school; 26 male (age 16.2±0.5yrs, 169.1±5.2cm, 58.0±5.6kg); 16 female (age 16.1±0.7yrs, 162.3±5.7cm, 54.7±5.0kg), or university; 50 male (age 20.0±1.2yrs, 172.5±6.4cm, 65.7±6.6kg); 7 female (age 20.7±1.1yrs, 163.4±3.1cm, 59.6±5.3kg).	Practice IR (/1000 hrs) higher in females than males & increased with age. Sex diff. in practice IR (1000 hour) (Junior male 0.9/1,000 hrs female 1.3/1,000 hrs. High School male 1.5/1,000 hrs female 2.4/1,000 hrs. University male 2.5/1,000 hrs 5.1/1,000 hrs) (p< 0.001). No sig. diff. (p=0.527) in match or practice in IR by AE's.
Monfort 2015 [182]; 16, 57% Moderate	Acute lower limb Injuries in Basketball & football	No demographic info reported. Data included from High School RIO tool for academic yrs 2005-2006 to 2011-2012. 9 sports, including basketball & football, from 100 schools strategically chosen to provide a nationally representative sample. 6,431,032 football & basketball AEs.	Female IR sig higher for both ball-handling & defending actions for both sports (p<0.05). Female knee IR & all-NC IR across sports & activities (p<0.05). Female higher ankle IR when ball handling in football (p<0.001). Football defending to ball-handling IR between competition & practice; female OR 1.88 (95%CI 1.01-3.48; p=0.047). Male No sig. Comp vs. Practice. Non-contact ankle injuries female basketball RR 1.58 (95%CI 1.01-2.50; p=0.045).
Muller 2017 [123]; 17, 61% Moderate	Acute & overuse injuries in (elite) Skiing	51 male, age 11.6±1.5yrs, height 153.4±9.0cm, weight 42.3±8.1kg, BMI 17.8±1.9, APHV 13.7±0.5yrs. 31 female, age 11.8±1.3yrs,	Acute IR 0.63/athlete, acute II 0.86/1,000 hrs (males, 0.9/1,000 hrs of training; females, 0.79/1,000 hrs of training). No sig. sex diff. in traumatic injuries between males & females (p=0.617, or the three groups of maturity (p=0.643; Figure 3, or the four relative age quartiles (p=0.3). Overuse IR rate 0.21 overuse injuries/athlete II 0.28/1,000 hrs of training (males, 0.4/1,000 hrs of training; females, 0.09/1,000 hrs of training). No sig. sex diff. in overuse injuries (p=0.81), the three groups of maturity (p=0.696), or among the four relative age quartiles (p=0.22). 42.7% athletes (35, 14 females, 21 males) had

		height 154.9±7.7cm, weight 43.8±7.9kg, BMI 18.1±2.2, APHV 12.0±0.5yrs.	acute injuries. 10.7% athletes had overuse injuries (13, 2 females, 11 males).
Nelson 2007 [183]; 17, 61% Moderate	Acute & overuse ankle Injuries-Boys' American Football, football, basketball, wrestling, & baseball; girls' football, volleyball, basketball, & softball	905 injuries. No demographic info included. High school sport.	Overall, ankle injury rates were higher in competitions than in practices (RR 2.58; 95%CI 2.26, 2.94; P.001). Overall, girls had an ankle injury rate that similar to boys (5.39 vs. 5.15/10 000 A-Es). In sports played by both sexes (football, basketball, & baseball or softball, boys had higher rates of practice-related ankle injuries, but girls had higher rates of competition-related ankle injuries. Proportion of ankle injuries higher female athletes (32.5%) than male athletes (18.4%). Football; injuries to the ankle were most frequent injury in both sexes, but the proportion of ankle injuries to total football injuries higher among female (31.5%) than male (23.5%). Basketball; male basketball had highest ankle IIR of all sports studied (7.74/10,000AE's) (vs. female 6.93, No sig. sex diff., slightly higher proportion in male than female basketball (39.7% vs. 36.5%, more male injuries sustained by forwards (the primary rebounding position) than female (46.2% vs. 26.0%, conversely in females greater proportion of ankle injuries tended to occur to guards (49.2% vs. 41.8%). Overall competition injury RR 2.58 (95%CI 2.26, 2.94; p<0.001). Female ankle IPR 1.77 (95%CI 1.53-2.05; p< 001). Football accounted for 33.6% all ankle injuries (boys 15.7%, girls 17.9%). Football female IPR 1.35 (95%CI 1.00, 1.81; p<05). Basketball playing position 'forwards' male IPR 1.78 (95%CI 1.21-2.62; p<01), basketball 'guards' female IPR 1.18 (95%CI 0.88-1.58; p<0.29). No sig. but in football male injuries from contact with another player, in females contact with equipment/apparatus.
O' Connor 2017 [184]; 16, 57% Moderate	Concussion in 27 American high school sports	Demographic info not included. High school age. 2004 sports related concussions analysed	Overall SRC rate 3.89/10 000 AEs all sports. Overall SRC rate highest American Football (9.21/ 10 000 AEs, followed by boys' lacrosse (6.65/10 000 AEs) & girls' football (6.11/10 000 AEs). During competitions, American Football (19.87/10 000 AEs, boys' lacrosse (17.51/10 000 AEs) & girls' football (17.16/ 10 000 AEs) had highest SRC rates. During practice, American Football (6.78/10 000 AEs), boys' wrestling (4.75/10 000 AEs) & girls' lacrosse (3.44/10 000 AEs) had highest SRC rates. Sex comparable sports overall SRC rate significantly higher in girls than in boys (2.64 vs. 1.69/10,000AEs) & in competition (girls-7.07, boys-4.86) & practices (girls-1.49, boys-0.85). Within specific sex-comparable sports, girls had increased SRC rates cf. with boys for softball (3.57/10,000AEs) or baseball (0.86/10,000AEs, basketball (4.44 vs. 2.52/10,000AEs, football (6.11 vs. 3.98/10,000AEs, & indoor track & field (0.52 vs. 0.14/10,000AEs). Overall SRC rate higher in competition than in practice (RR 3.30 [95%CI 3.02-3.60]). Collective overall SRC rate higher in girls than in boys (RR 1.56 [95%CI 1.34-1.81]). During competition, girls RR1.46 (95%CI 1.20-1.77) times SRC rate of boys, increasing to RR 1.75 (95%CI 1.39-2.20) times SRC rate during practices. Distributions of number of symptoms reported between male & female in sex comparable sports No sig. diff. (p=0.09). Most athletes with SRCs reported symptom resolution < 7 days (40.7%, 814) or 8 to 14 days (21.7%, 234). Among sex-comparable sports, the proportion of SRCs with symptom resolution time within 7 days was sig.

			higher in boys than in girls (44.4% [142] vs 32.2% [122]; IPR 1.38 (95%CI 1.14-1.67). In contrast, the proportion of SRCs with symptom resolution time greater than 14 days was sig. higher in girls than in boys (33.0% [125] vs 24.4% [n78]; IPR 1.35 (95%CI 1.06-1.72). The proportion of SRCs with symp-tom-resolution time greater than 28 days was also higher in girls than in boys No sig. (14.8% [56], vs 10.3% [33]; IPR 1.43 (95%CI 0.96-2.15). Overall, 211 (10.5%) players RTP time less than 7 days. Among sex-comparable sports, proportion of athletes with SRCs RTP less than 7 days was sig. higher in boys than in girls (14.1% [45] vs 8.4% [32]; IPR 1.67 (95%CI 1.09-2.56). Conversely, 23.0% (461) of all athletes & more girls than boys (28.2% [107] vs 14.7% [47]; IPR 1.92 (95%CI 1.41-2.62) RTP greater than 28 days.
O' Connor 2020 [60]; 16, 57% Moderate	All injuries in junior tennis	Injuries in Irish national junior tennis program (n=82) over two yrs were collected in a prospective cohort study. Age 8-22yrs.	54% players sustained an injury over the study period. No sex diff. in injury rates IRR 1.05 (95%CI 0.72-1.5). Trend towards females having a greater proportion of shoulder injuries (female 23.5%, male 10.9%), males having a greater proportion of knee injuries (male 29.1%, female 7.8%).
Olsen 2006 [45]; 18, 64% Moderate	Acute & overuse injuries in youth Handball	90 teams; 75 female teams (900 players) & 15 male teams (180 players). The players on these teams were all amateurs, depending on ability & ambition, they practiced 1-5 times/wk & played between 20 & 50 matches during season. Injured players mean age 16.4±0.5yrs (range 15-17).	No sig. sex diff. in overall injury rate (female 14.5, male 8.3 injuries per 1,000 player hrs). No further sex analysis. Female RR 1.8 (95%CI 0.9-3.4).
Pierpoint 2016 [124]; 16, 57% Moderate	Acute & overuse injuries in high school Track & Field	1317 female injuries reported. 1168 male injuries reported. No further demographic info	Sig. sex diff. in IIR; overall-Female 0.99/1,000 AE's male 0.72 & in practice-female 0.93/1,000 AE's male 0.58. (No sig. in competition IIR). Stress fractures & shin splits accounted for 2.1% & 3.3% boys' injuries, respectively. Stress fractures & shin splits accounted for 4.6% & 4.8% girls' injuries, respectively. A sig. greater proportion of female injuries were chronic/overuse in nature (~40%, male ~30%). Female overall RR 1.37;

		reported. High school sport.	(95%CI 1.27-1.48). Female practice RR 1.60 (95%CI 1.46-1.76). Female competition RR 0.93 (95%CI 0.80-1.07). Female chronic/overuse IPR 1.32 (95%CI 1.14-1.52).
Pieter 2010 [46]; 17, 61% Moderate	Acute & overuse injuries in Karate	302; 218 male, 84 female. Ages 7-15yrs.	No sig. sex diff. in IIR 1000 AE or 100 ME; male 99.74/1000AE, female 115.11 & male 13.30/100ME, female 15.35. No sig. sex diff. in overall IR male 34.86/100 athletes, female 38.10. Female were not considered to be at a higher risk of injury. No sig. sex diff. on anatomic location or type of injury. Overall female RR 1.093 (95%CI 0.788-1.516, p=0.596).
Powell 2000 [47]; 16, 57% Moderate	Acute & overuse injuries in Baseball/Softball, Basketball & football	8988 reportable injuries: 4559 male (50.7%) & 4429 female (49.3%). High school sport.	Sig. sex diff. in overall injury for Softball 16.7/100p plyrs, Baseball 13.2 (p< 0.001). Baseball players, shoulder/arm category accounted=19.7%; Softball players, the shoulder/arm=16.3% injuries. Baseball injuries evenly divided between practice (49.4%) & games (50.6%, Softball, practices accounted for 55.9% injuries (p<0.001). Player position & injury category similar between Softball/Baseball. No sig. overall in Basketball. Girls' basketball a higher proportion of major injuries than did the boys' teams (p<0.05). Female basketball more surgeries (p<0.02). Female basketball had a higher proportion of game-related injuries (46.8%) than did the boys' teams (42.0%) (p<0.01). Sig. sex diff. in football; general trauma injuries & fractures male (29.9%, female (24.9%) (p<0.01, reinjuries in female (10.4%, male (8.4%) (p<0.04), injuries requiring surgery female (3.09%, male (2%) (p<0.001). Overall Softball IDR 1.27 (95%CI 1.15-1.39). Female overall football IDR 1.14 (p<0.001). Female knee Basketball IDR 1.44. Female knee surgery Basketball knee surgery IDR 2.65. Female Basketball ACL surgery IDR 4.15. Female football knee injuries IDR=1.46, Female football knee surgeries IDR 3.66 & female football ACL surgeries IDR 3.41.
Pytiak 2018 [185]; 18, 64% Moderate	Acute & overuse injuries in Baseball/Softball	299 injuries; male=214, female=75. High school sport.	Overall IIR softball 1.22/1000AEs, baseball 1.01/1000AEs (p<0.05). Sex diff. in elbow IIR; Baseball 0.92/10,000AE's, Softball 0.43 (p<0.05). Greater proportion baseball injuries (9.2%) than softball injuries (3.6%). Elbow injuries were sig. more likely to occur in competition than practice in baseball; this was not shown for softball. Baseball injuries were more likely to require surgery than softball injuries (6.2% vs 0.0%; p=0.02). Overall Softball RR 1.21 (95%CI 1.15-1.29). Elbow Baseball RR 2.12 (95%CI 1.64-2.77). Baseball elbow IPR 2.58 (95%CI 1.99-3.33). Baseball competition elbow injury RR 2.24 (95%CI 1.71-2.93). Softball competition elbow injury RR 1.14 (95%CI 0.71-1.81). Baseball ligament sprains; IPR 1.70 (95%CI 1.02-2.84). Softball tendinitis IPR 0.62 (95%CI 0.40-0.96). If all injuries occurring during pitching were removed from both baseball & softball; no sex diff. (non-pitching baseball RR 1.19 [95%CI, 0.88-1.62]).

Rauh 2000 [186]; 17, 61% Moderate	Acute & overuse injuries in cross country	n=3,233. 1,202 females (from 99 teams). 2,031 males (from 100 teams). Age 14-18. From 23 high schools.	Overall IIR 13.1/1,000 athletic exposures (AEs). Sig sex diff. for overall IIR; females 16.7/1,000 AEs, males; 10.9/1,000 AEs (p < 0.0001). Female had sig. (p < 0.0001) higher IIR for initial injury (10.4/1,000 AEs v 7.6) & subsequent injuries (48.5/1,000 AEs v 35.5), particularly at same body location (44.1/1000AEs v 32.2). New injury highest overall IIR was at the shin (1.9/1,000 AEs) & highest reinjury at the same body location (53.9/1,000 AEs). Female had sig. higher initial IIR than males for shin (2.8/1,000 AEs v 1.4), hip (0.7/1,000 AEs v 0.4), & foot injuries (1.0/1,000 AEs v 0.5), & higher reinjury rates for knee (50.8/1,000 AEs after initial injury v 33.5), calf (75/1,000 AEs v 13.6), & foot (84.1/1,000 AEs v 29.2) injuries. Overall, higher IIR during practices (9.2/1,000 AEs) than meets (7.8/1,000 AEs) IRR 1.2 (95%CI 1.0-1.4). In males, injuries in practice sig. greater than in meets RR; 1.5 (95%CI 1.1-2.0). No sig. diff. between practice & meet in among females. Female had higher rates of injuries than males for meets; IRR 2.1 (95%CI 1.5-3.1) & practices IRR 1.4 (95%CI 1.2-1.6).
Schroeder 2015 [127]; 14, 50% Moderate	Overuse Injury in American Football, Boys wrestling, Boys ice hockey, Girls field hockey, Girl's gymnastics, Cheerleading, Lacrosse, Swimming, Track & Field, Football , Volleyball, Basketball, Baseball/softball	No demographic info reported. High school sport.	Sports with highest % all injuries that were overuse; male & female swimming (55.7 & 44.7%), track & field (28.5 & 36.8%). Sports with lowest % all injuries that were overuse male ice hockey (1.4%), male volleyball (2.4%). Overuse injuries more likely in practice than competition. When all 20 sports were evaluated, IIR higher in females (1.88/10,000AE's) than males (1.26). Sex-comparable sports IIR higher in female (2.08) than male (1.44). Practice IIR higher in female (2.27) than in male (1.34). Across all sports overall injury; female RR 1.50 (95%CI 1.39-1.61). Sex comparable sports overall injury; female RR 1.45 (95%CI 1.32-1.58). Sex comparable sports, female RR 1.69 (95%CI 1.56-1.83). Overall, overuse injuries represented 13.3% all injuries in girls but only 5.5% all injuries in boys.
Stracciolini 2014 [188]; 16, 57% Moderate	Acute & overuse injuries	n=2133. 1151 females, 982 males.	Sig. sex diff.; overall overuse female 62.5% male 41.9%, traumatic female 37.5%, male 58.2%; lower extremity female 58.8% overuse, males 56.2% traumatic; hip/pelvis female 90.9% overuse, males 58.3% traumatic; spine female 93.9% overuse, males 18.8% traumatic. Injury location differed by sex; females 65.8% lower extremity injury, 15.1% upper extremity, 6.7% hip/pelvis & 11.3% spine, male 53.7% lower extremity injury, 29.8% upper extremity, 3.7% hip/pelvis & 8.2% to the spine. Sig. sex diff. for injury diagnosis; fracture male 19.5%, female 8.2%, PFPS male 4%, female 14.3%, OCD male 8.6%, female 4.3%, instability male 4.3%, female 7.3%, SH fracture male 7%, female 4.1%. On average, male & female patients participated in a total of 2.4 activities. A higher proportion of male patients played contact/collision sports (68.9%, female 43.3%; p<0.001). Data between sexes not adjusted for sport type; therefore, some patterns observed likely due to demand of sport e.g. female spine overuse in gymnastics.

Stracciolini 2015 [71]; 18, 64% Moderate	Overuse Injury in multiple team & individual sports	1614; mean age=14.2, BMI z score 0.5. 872females; mean age=14.2, BMI z score 0.4. 742 males; mean age=14.2, BMI z score 0.6.	Sig. sex diff. for all injury sites; Head male 3.4%, female 0.7% (p<0.001), Chest male 2.4%, female 0.6% (p<0.002), Upper extremity male 30.5% female 14.2% (p<0.001), Lower extremity male 53.4% female 66.8% (p<0.001), Hip/pelvis-male 3.8% female 7.1% (p<0.004), Spine male 7.7% female 11.3 (p<0.013). 45.9% sex diff. can be accounted for by distribution of background & characteristics (age, BMI, prior injury, type of sport). Team sports increased odds of being seen for overuse (vs traumatic) injury in both males (OR 5.329 [95%CI 3.026-9.383]; p=0.001) & females (OR 1.27 [95%CI 0.824-1.979]; p<0.274). 63% females had overuse injuries vs. 40% males (p<0.001). Analyses accounted for participating in sports that are associated with high overuse injury rate.
Swenson 2009 [132]; 16, 57% Moderate	All recurrent injuries in Baseball/softball, Basketball, American Football, Football, volleyball, Wrestling	High school athletes. No specific demographic data included. RIO - from 2005-2008, 13 755 injuries during 5 627 921 AEs	Overall IR 24.4/10 000AE's. Recurrent injuries accounted for 10.5% all injuries. American Football players had highest rate of recurrent injury (4.36/10 000 AE's). Sig. sex diff. for recurrent injuries in football; female 2.55 male 1.83. cf. with the other 7 sports, Basketball had greater proportion of recurrent injuries: Male (IPR 1.24 [95%CI 1.03-1.50]) & Female (IPR 1.53 [95%CI 1.27-1.86]). In sex comparable sports sig. diff. only in football, female; RR 1.39 (95%CI, 1.07-1.82). In 6/9 sports, recurrent injuries sig. more likely to occur in competition than practice, especially in American Football; RR 4.69 (95%CI 4.02-5.46) & female football; RR 3.89 (95%CI 2.69-5.60).
Swenson 2010 [131]; 20, 71% Moderate	Acute fractures in American Football, volleyball, basketball, football, wrestling, baseball, softball.	No demographic information. RIO from 2005–2009, 18,316 total injuries during 7,740,400 AEs.	Fractures were 4th most common diagnosis after ligament sprains, muscle strains, contusions. The highest rate of fractures was in American Football (4.61/10 000AE's) & the lowest in volleyball (0.52). Basketball boys 1.86/10,000AE's, girls 1.39. Football boys 2.17, girls 1.62. Baseball (15.4%) & softball (13.4%) had highest proportion of injuries that were fractures. Basketball boys RR 1.35 (95%CI 1.06-1.72) football boys RR 1.34 (95%CI 1.05-1.71). Overall competition (vs. practice) RR 3.21 (95%CI 2.93-3.52). This held for every sport except volleyball RR; 0.84 (95%CI, 0.40-1.77). In sex comparable sports boys practice RR (1.39; 95%CI 1.09-1.78); competition RR 1.17 (95%CI 0.97-1.41).
Swenson 2012 [130]; 19, 68% Moderate	Sports related fractures in American Football, volleyball, football, basketball, baseball/softball, wrestling.	No demographic info included. High school sports in the USA. RIO - during 2008-09 to 2010-11, ATs from the 11,625 injuries during 5,640,505 AEs. 2103 Fractures reported. 9% all injuries over the reporting period.	Overall rate of 1.82 fractures/10,000 AEs. Highest IR-football (4.37, male ice hockey (3.08, & male lacrosse (2.59). Overall male had significantly higher IR in competition (5.59 vs. 1.98) & practice (1.98 vs. 0.56). Male sustained 79.1% all fractures. Overall male competition RR 2.82 (95%CI 2.45-3.24) & practice RR 2.43 (95%CI 2.07-2.86). Using linear regression, we found the proportion of all injuries that were fractures was inversely correlated with the athlete’s age (p=0.02) but not with Athletes’ age-and gender-adjusted BMI. Overall Male IPR 1.57; (95%CI 1.42-1.74), Male lacrosse IPR 2.38 (95%CI 1.47-3.85), & Male football IPR 1.81 (95%CI, 1.42-2.30). No sig. sex diff. for basketball baseball/softball, track & field or volleyball. Recurrent fractures no sig. sex diff. overall or in gender-comparable sports.

Swenson 2013 [129]; 16, 57% Moderate	Acute ankle injury in American Football, volleyball, football, basketball, swimming, baseball/softball, wrestling, field hockey, ice hockey, gymnastics, track & field.	No demographic info included. From RIO - during 2005/06 to 2010/11, 7807 ligament sprains (30.5% all injuries) of which 4108 were ankle sprains.	Overall rate 2005-11 3.13/10 000 AE's (Boys IR 3.14/10 000 AEs & girls 3.11/10 000 AE). Sports with the highest IR; boys' basketball (5.16/10 000 AEs, girls' basketball (5.03) & girls' gymnastics (4.88). The highest competition IR boys' football (15.01/10 000 competition AEs, girls' basketball (9.45, girls' football (9.41, & girls' gymnastics (9.36). Highest practice IR boys' volleyball (3.83/10 000 AEs, girls' gymnastics (3.82, girls' volleyball (3.79, & boys' & girls' basketball (3.79 & 3.13, respectively). Rates were higher for girls than for boys RR 1.25 (95%CI 1.17-1.34) in sex-comparable sports. Rates were higher in competition than practice for boys RR 3.42 (95%CI 3.20-3.66) & girls RR 2.71 (95%CI 2.48-2.95). Girls were sig. more likely to sustain ankle sprains than boys in football (RR 1.46 95%CI 1.29-1.66), softball/baseball (RR 1.65 95%CI 1.29-2.12), track & field (RR 2.18 95%CI 1.44-3.31). Overall, ankle sprain rates were higher in competition than in practice for boys' RR 3.42 (95%CI 3.20-3.66) & girls' RR, 2.71 (95%CI 2.48-2.95) sports.
Swenson 2013 [128]; 16, 57% Moderate	Acute & overuse knee injuries in American Football, football, gymnastics, volleyball, basketball, baseball/softball, lacrosse, swimming & diving, & track & field.	No demographic info included. RIO – during the 2005/06–2010/11, 5116 knee injuries reported during 17,172,376 AEs.	Overall rate of 2.98 knee injuries/10,000 AE. Highest IR in American Football 6.29/10,000 AE's, female football (4.53) & female gymnastics (4.23). Most commonly involved structure was the MCL (36.1%), patella/patellar tendon (29.5%), ACL (25.4%), meniscus (23.0%), LCL (7.9%), & PCL (2.4%). American Football & girls' football had highest rate of ACL injury (1.17/10,000 AEs) female gymnastics (1.14) & female basketball (1.07). American Football only sport with meniscal IR over 1/10,000 AEs & highest MCL IR (2.42/10,000 AE). Overall competition RR 3.53 (95%CI 3.34-3.73). In sex comparable sports female RR 1.52 (95%CI 1.39-1.65). Female ACL injury RR 2.38 (95%CI 1.91-2.95). Female IPR 1.30 (95%CI 1.11-1.53). Football female RR 1.71 (95%CI 1.50-1.95), basketball female RR 1.89 (95%CI 1.62-2.20, baseball/softball female RR 1.68 (95%CI 1.28-2.21, track & field female RR 1.49 (95%CI 1.08-2.06). Overall ACL female RR 1.01 (95%CI 0.87-1.17). In sex comparable sports ACL female RR 2.38, (95%CI 1.91-2.95). ACL softball female RR 4.99 (95%CI 1.86-13.36), basketball female RR 4.54 (95%CI 2.99-6.89) & football female RR 2.33 (95%CI 1.67-3.26). Not including ACL in this paper analysis or discussion.
Tirabassi 2016 [189]; 16, 57% Moderate	Acute &overuse injuries in wrestling, American Football, football, gymnastics, volleyball, basketball, baseball/softball, ice hockey, lacrosse, swimming & diving, & track & field, cross country.	No demographic info included. RIO - 2005/6-2013/14	Overall MDQ IIR 11.8/100,000AEs. MDQ IIR Competition 28.0/100,000AEs, Practice 6.3/100,000AE's. In sex comparable sports sig sex diff; overall male MDQ 14.4 vs. female 8.0. Highest MDQ IIR; American Football 26.5/100,000 AEs, gymnastics (18.6) wrestling. Other sports with IIR above 10/100,000 AEs; female football (16.5), male lacrosse (15.8), male ice hockey (12.3), & female basketball (11.2). MDQ IIR higher in female basketball 11.2 (male 6.9), cross-country 5.6 (male 2.1), football 16.4 (male 10.5) & track & field 4.8 (male 1.8). Competition (vs. training) RR 4.4 (95%CI, 4.1-4.7). Overall MDQ male RR 1.8 (95%CI, 1.7-1.9). MDQ basketball female RR 1.6 (95%CI 1.3-2.0), female cross-country RR 2.6 (95%CI 1.0-7.5), female football RR 1.6 (95%CI 1.3-1.9), & female track & field RR 2.6 (95%CI 1.7-4.0). In football; proportion of all MDQ injuries that were concussion 12% in female athletes & 6% in male athletes. In male athletes, fracture was the most common diagnosis in 3 sports, sprain/strain most common diagnosis in 6 sports. In female athletes; sprain/strain most common diagnosis in 9 sports.

Yard 2008 [133]; 16, 57% Moderate	Acute & overuse injuries in football.	No demographic info included. RIO - 2005-07 1524 football injuries during 637446 AEs.	Overall study injury rate 2.39/1000 AEs. Higher in competition (4.77) than practice (1.37). No sig. sex diff. in overall IIR (female-2.44 & male-2.34). Female sig higher competition IIR (5.34 vs. 4.26). Male sig. higher practice IIR (1.51 vs. 1.21). During competition, females sustained complete knee ligament sprains requiring surgery at a rate of 26.4/100 000 AEs (male 1.98/100 000 AEs) (RR 13.3 [95%CI, 3.15-56.35]) & higher than female practice (2.34/100 000 AEs). Competition (vs. practice) RR=3.49; (95%CI, 3.15-3.87). Female (vs. male) competition RR=1.25; (95%CI, 1.10-1.42). Male (vs. female) practice RR 1.24 (95%CI 1.06-1.46). Male sustained a larger proportion of contusions than females (IPR 1.60 [95%CI 1.19-2.15]), while females sustained a larger proportion of complete ligament sprains (IPR 2.72 [95%CI 1.33-5.60]). Male hip injuries (vs. female) IPR 3.27 (95%CI 1.70-6.28). Female (vs. male) knee injuries IPR 1.42 (95%CI 1.09-1.84). Female (vs. male) knee ligament sprains IPR 3.41 (95%CI 1.39-8.39). Female (vs. male) competition knee ligament sprain RR 13.3 (95%CI 3.15-56.35). Female competition (vs. female practice) competition knee ligament sprain RR 11.3 (95%CI 4.31-29.58). Overall, females accounted for 51.6% football-related injuries. Most frequent injuries=incomplete ligament sprains (male 24.2% & female 29.2%) & incomplete muscle strains (male 18.8% & female 17.1%). Concussions-similar proportions (male 9.3% & female 12.2%). Overall, males & females sustained ankle (22.0% & 24.7%, respectively, knee (15.4% & 21.8%, respectively, head/face (13.2% & 14.5%, respectively, & thigh/upper leg (14.6% & 11.7%, respectively) injuries most often. Similar rates between sexes of time loss injuries for <1wk, 1-3 wks & >3 wks. Male injuries resulting in >3 wks' time loss; concussions (11.0% all male >3 wks' time loss, incomplete ankle ligament sprains (9.3%), complete knee ligament sprains (8.1%), foot fracture (5.9%), shoulder fracture (5.8%), & arm fracture (5.6%). Female injuries >3 wks' time loss-complete knee ligament sprains (28.4%), ankle fracture (9.0%), incomplete knee ligament sprains (8.3%), concussions (7.4%), & incomplete ankle ligament sprains (5.1%). Males & females sustained a similar proportion of concussions (9.3% & 12.2%, respectively) (IPR 1.31 95%CI 0.91-1.88).
COMBINED AGE GROUPS			
Achenbach 2018 [73]; 17, 61% Moderate	Acute & overuse injuries in handball.	Twenty U17 teams (8 female, 21 male) from 16 different nations. 200; age 16.3±0.8yrs played 7.1±0.6 matches in 3 days; injury data from 200 u-17 players (120 Male, 80 Female) were evaluated. Ten senior teams from 16 different nations. 100; age 26.1±6.2yrs	Overall (Senior & U17) 77 (26%) players sustained 87 injuries yielding; overall IIR 286.1 injuries/1000h. U-17 players 205.7/1000h (v senior 395.5/1000h). Male athletes 330.2 injuries/1000h & Female athletes 234.9/1000 hrs (not sig.). Senior players OR 0.29 (95%CI 0.17-0.50; p<0.01). Male athletes OR 0.76 (95%CI 0.45-1.28, n.s). 63.2% resulted from non-contact mechanism, 16.1% from overuse injuries. Thigh was body site most affected by contact injuries (66.7%), & ankle was body site most affected by non-contact injuries (83.3%). Sex analysis not done within age group, injury type or body site. (Overall, 82 injuries (82.8%) required medical attention. Fifteen (17.2%) injuries were time-loss injuries; incidence 49.3/1000 hrs.

		played 11.1±1.6 matches in 5 tournament days; injury data of 100 senior players (40M, 60F) evaluated.	
Beynnon 2005 [64]; 18, 64% Moderate	Acute ankle injury in football, basketball, lacrosse & field hockey.	663 high school (416 female), 238 college (128 female) athletes. Female athletes mean age 16.5 yrs (range, 13-22 yrs), height 166.1cm (range, 149.9-200.7 cm) & weight 59.0 kg (range, 40.5-85.5 kg). Male athletes mean age 17.2 yrs (range, 13-24 yrs), height 178.6cm (range, 152.4-203.2 cm) & weight 73.6 kg (range, 45.0-121.5 kg).	Overall, 29 female athletes (5.3%) & 14 male athletes (3.9%) sustained injuries. Female IR 0.97/person days (95%CI 0.65-1.39) & male IR 0.68/person days (95%CI 0.37-1.13) No sig. (p=0.20), Female RR 1.51 (95%CI 0.79-2.86). Overall high school IR 0.80 (95%CI 0.53-1.14), college IR 0.99 (95%CI 0.54-1.65), College RR 1.16 (95%CI 0.61-2.21). High school: Female IR 0.90 (95%CI 0.55-1.40), male IR 0.63 (95%CI 0.29-1.19), female RR 1.53 (0.69-3.41). College: female IR 1.15 (95%CI 0.53-2.19), male IR 0.78 (0.25-1.82), female RR 1.50 (0.50-4.48). Sport specific IRs (no sig se diff.); Basketball - female 1.90 (95%CI 0.95-3.40), male 0.42 (95%CI 0.05-1.54), football female 0.73 (95% 0.24-1.70), male 1.15 (95%CI 0.50-2.26), Lacrosse female 0.62 (95%CI 0.23-1.37), male 0.44 (95%CI 0.12-1.13). Overall female RR 1.51 (95%CI 0.79-2.86). Female basketball RR 4.11 (95%CI 0.91-18.60; p=0.046), female football RR 0.69 (95%CI 0.23-2.14; p=0.52) female lacrosse RR 1.40 (95%CI=0.39-4.96; p=0.60). College RR 1.16 (95%CI 0.61-2.21; p=0.64). Sex analysis within high school & college athletes no sig. diff. reported (specific data not included).
Opar 2014 [35]; 16, 57% Moderate	Acute hamstring injury in track & field.	48,473 athletes registered to participate in the Penn Relays Carnival (2002-04 inclusive). Male = 25,232 (junior 912, high school 14,514, college 9113, masters 693), female = 23,241 (junior 912, high school 14,372, college 7915, masters 42). Competition levels; junior high school, age≤13 yrs; high school, age 14–18 yrs; college/elite (including pre-	Overall IR, male=3.0/1,000 participants, female IR=1.7. High school IR male=2.9/1,000 participants, female IR=1.7/1,000. Overall male HSI OR 1.79 (95%CI 1.23-2.63; p=0.002). Excluding masters athletes, male HSI OR 1.68 (95%CI 1.14-2.47; p=0.009). No junior high school or masters women reported HSIs during study period. High school female HSI OR 0.55 (95%CI 0.33-0.92; p=0.021). No junior high school athletes were diagnosed with HSI. Masters HSI (v high school) OR 4.26 (95%CI 1.95–9.33; p< 0.001). Masters HSI (v college/elite-level) OR 3.55 95%CI 1.60–7.89; p=0.001). High school HSI (v college/elite-level athletes) OR 0.83 (95%CI 0.57–1.22; p= 0.342).

		Olympic/professional athletes) age 19–40 yrs; or masters age >40 yrs.	
Opar 2015 [34]; 16, 57% Moderate	Acute & overuse injuries in track & field	48,473 athletes registered to participate in the Penn Relays Carnival (2002-04 inclusive). 25,232 males (junior 912, high school 14,514, college 9113, masters 693), 23,241females (junior 912, high school 14,372, college 7915, masters 42). Competition levels; junior high school, age≤13 yrs; high school, age 14–18 yrs; college/elite (including pre-Olympic/professional athletes) age 19–40 yrs; or masters age >40 yrs. 436 injuries sustained from competing athletes. (Medical & orthopaedic injuries reported, medical injury data not considered within this review).	Minor orthopaedic injuries; 5.71/1,000 participants, major orthopaedic injuries 0.18/1,000 participants. Minor orthopaedic injuries male OR, 1.36 (95%CI 1.06-1.75; p=0.017). Secondary analysis excluding all masters athletes; overall male OR 1.10 (95%CI, 0.91-1.33; p=0.303), major orthopaedic injuries male OR 0.71 (95%CI 0.16-3.17; p=0.651). Minor orthopaedic injury male OR 1.32 (95%CI 1.02-1.69; p=0.032). College/elite female athletes (ref high school female athletes) OR 0.71 (95%CI, 0.52-0.98; p=0.036). College male athletes (ref college female athletes) OR 1.77 (95%CI 1.13-2.79; p=0.012). College/elite athletes (ref high school) injuries OR 0.81 (95%CI 0.66-0.99; p=0.041). College athletes injuries (ref masters) OR 0.49 (95%CI 0.27-0.88; p=0.001). High school athletes major orthopaedic injury (reference group masters) OR 0.05 (95%CI 0.00-0.56]; p=0.003). High school athletes minor orthopaedic injury OR 0.43 (95%CI 0.22-0.85; p=0.012) (reference group masters).

Roos 2015 [187]; 17, 61% Moderate	Overuse injuries in baseball/softball, basketball, American Football, football, cross country, track & field, swimming & diving, tennis, volleyball.	Collegiate (17-23yrs) & High school (14-16yrs) age athletes. No demographic info. included.	In sex-comparable sports females had higher rates of overuse injury than males. College females highest rate of overuse injury (7.32/10,000 AEs), & HS boys lowest rate of overuse injury (1.42/10,000 AEs). Rate of overuse injury higher in college athletes (5.36/10,000 AEs) than in HS athletes (1.64/10,000 AEs) ($p<0.05$). Among sex-comparable sports, High School athletes female RR 1.55 (95%CI 1.43-1.68). College athletes female RR 1.25 (95%CI 1.16-1.35). College athletes overuse RR 3.28 (95%CI 3.12-3.44) (ref High School). Highest rates of overuse injury (expressed as injuries/10,000 AEs) were female cross country (college, 19.59; HS, 6.73), male cross country (college, 13.67; HS, 4.02), female outdoor track & field (college, 15.76; HS, 3.82), & male outdoor track & field (college, 13.53; HS, 2.13). College football only sport where male overuse injury rate higher than female (5.10 vs 4.19 per 10,000 AEs). Among sex-comparable sports female RR slightly higher in HS athletes (1.55 [95%CI 1.43-1.68]) than college athletes (RR 1.25 [95%CI 1.16-1.35]).
Vaandering 2022 [61]; 17, 61% Moderate	All injuries in volleyball.	2018 Canadian Youth National Volleyball Tournament 65requiring65 players in all age categories (U14, U15, U16, U17, & U18) & divisions of play (Division 1-5) were invited to participate (9616 players). Participants n=1,876 players [466 males, 1391 females, mean age 16.2 yrs±1.26)] consented to participate (19.5%).	IIR female 6.78 injuries/1000 AEs (95%CI 5.27-8.72), male 4.30 (95%CI 2.55-7.24), female IRR 1.47 (95%CI 0.80-2.69); point estimate suggests clinical relevance. Highest proportion of injuries in females head (40.96%), ankle (15.66%), knee (14.85%). Highest proportion of injuries in males finger (33.33%), head (16.67%), knee (16.67%). Overall concussion IIR 1.58 concussions/1000 AEs (95%CI 1.06-2.36). Females had a higher proportion of concussion diagnosis, female 27.71%, male 16.67%. Concussion female RR 2.62 (95%CI 0.76-9.04); point estimate suggests clinical relevance.

OR: odds ratio; aOR: adjusted odds ratio; CI: confidence interval; HR: hazard ratio; IRR: incidence rate ratio; RR: relative risk; IQR: interquartile range.

Table 7 Participant characteristics and main findings for the Tier-2 athlete studies.

Reference & Quality score	Focus	Participants characteristics, age (mean±SD)	Findings/comments
ADULT			
Dane, 2004 [190]; 11, 39% Limited	Acute & overuse injuries – not reported separately. Football, basketball, volleyball (Team). Running, wrestling (Individual).	329 males (72%); 127 females (28%). 17-28 yrs. Male; 106 football, 58 basketball, 62 volleyball, 45 runners, 58 wrestlers. Female; 55 basketball, 47 volleyball, 25 runners.	No sig. sex diff. in any sport in percentages of injured athletes. Basketball: male IR 84.5% vs female 78.2%. Volleyball: male IR 80.7% vs female 74.5%. Running: male IR 60% vs female 52%. No sex analysis for anatomical location of injury.
Gill, 2021 [81]; 13, 46% Limited	Acute & overuse injuries in Australian Rules football.	1635 patients attending ED study site during 10-month study; (242; 14.8% female). Age 20.2±7.8) yrs (49.1% patients <18 yrs old). Females 20.7±8.1 yrs, males 20.1±7.8 yrs.	68.9% game injuries. Sprain/strain injuries; female 50.4% all injuries, male 38.8% (p<0.05). Skin lacerations female 1.7%, male 8.0% (p<0.05). Hand or finger injuries; female 34.3%, male 23.4% (p<0.05). Cervical spine injuries; female 6.6%, male 2.5% (p<0.05). Shoulder injuries; female 5.8%, male 11.5% (p<0.05). Thorax/abdomen/pelvic injuries; female 2.1%, male 5.7% (p<0.05). Concussion was diagnosed in 14.1% patients, females 15.7%, males 13.8% (NS). Knee injuries; female 9.9%, males 7.0% (NS). Patellofemoral dislocations female 2.9%, male 0.6% (p<0.05). ACL injuries, female & male (not sig.).
Hollander, 2018 [39]; 16, 57% Moderate	Acute & overuse injuries – not reported separately. Indoor & outdoor hockey.	232; 68% 157 male, 75 female. 190 played both seasons; some players exclusively played during outdoor (36) or indoor season (6). Mean age±SD of players was 20.7±4.7 yrs with sig. diff. between male (20.0±4.8 yrs) & female (22.0±4.3 yrs) (p<0.01). BMI (female 22.8±2.3, male 23.1±2.8 not sig.).	Overall IIR: male 3.8/1000 hrs (95%CI 3.1-4.5) vs female 3.5/1000 hrs (95%CI 2.9-4.2) not sig. Match IIR: male 9.8 (95%CI 7.9-11.6) vs female 9.6 (95%CI 7.8-11.4) not sig. Practice IIR: male 2.7 (95%CI 2.2-3.2) vs female 2.7 (95%CI 2.2-3.2) not sig. Indoor IIR: male 2.7 (95%CI 2.15-3.2) vs female 5.00 (95%CI 4.1-5.9) & outdoor IIR: male 4.5 (95%CI 3.7-5.4) vs female 2.8 (95%CI 2.3-3.4). More male players injured than female players (40.5% vs 27.0%, p<0.01). Data collected over 12 months.
Hollander 2021 [82]; 19, 68% Moderate	Running injuries.	550 injured recreational runners: 49.6% women; 37.0±12.8 yrs; 23.3±3.0 kg/m.	141 knee (25.7%), 119 lower leg (21.6%), 85 foot/toes (15.5%), 71 hip/groin (12.9%) injuries. Strongest associations between risk factors & injury locations for sex (female) with hip/groin & thigh injuries, & midfoot striking with Achilles tendon injuries. Hip female RR 2.22 (95%CI 1.43–3.45). Thigh female RR 2.65 (95%CI 1.45–4.87). Achilles tendon injury male RR 1.92 (95%CI 1.09–3.38). Individuals with midfoot strike pattern RR 2.27 (95%CI 1.17–4.41).

Mintz 2021 [158]; 14, 50% Moderate	All injuries in track & field.	NEISS (ED) database 2004-15. Age >18 yrs. 2004-15. 42,947 ED visits for track & field-related injuries in the US, with an estimated 23,509 (54.7%) male, & 19,438 (45.3%) female. Most ED visits for 18–22 year olds, male 12,288 (52.3%), female 9,441 (48.6%).	No sig. sex diff. overall or by severity, mechanism of injury or anatomical location of injury. Trend towards higher proportion of male injuries 67requiring hospitalisation (male 2.9%, female 1.7%; p=0.32). Trend towards higher proportion of female injuries to the lower limb (female 70.8%, male 63.7%). Trend towards higher proportion of male injuries to the upper limb (male 15.7%, female 8.7%).
Morrissey 2020 [159]; 15, 54% Moderate	All injuries in adult ice hockey.	NEISS (ED) database 2007-16. Age >18 yrs. 2007-16. 1,653 ED visits for ice hockey injuries in US. Patients represented an estimated 68,786 total ice hockey related injuries, male 62,990 males (92%), 5,796 females (8%). Most commonly injured age group was youngest cohort studied, aged 19–25 yrs old (31,385, 46%).	Female head injury IPR 2.4 (95%CI 1.7–3.3, p < 0.001)(female 32%, male 13.3%). Male facial injury IPR 3.7; 95%CI 2.0–13.3, p < 0.01) (male 19.3%, female 5.2%). Male laceration injuries IPR 3.5 (95%CI 2.3–6.2; p < 0.001) (male 28.1%, female 8.1%). Female concussion IPR 2.3 (95%CI 1.3–3.5; p < 0.001) (female 14.3%, male 6.3%). Primary injury mechanisms for females; falls (29.5%), puck contact (24.3%) & player contact (11.1%), for males; falls (19.3%), player contact (17.3%) & puck contact (14.7%). Although not a top injury mechanism, male stick injuries IPR 3.9 (95%CI 1–169; p=0.07). (n = 4,712, 7.5%) than females (n = 110, 1.9%).
Rugg 2021 [160]; 18, 64% Moderate	Snowboarding injuries.	National registry data – snowboard related emergencies 2005-18.	Male injuries per season declined sig. across seasons (p=0.001), female injuries remained stable, therefore proportionally increased (p=0.035). Contusions, strains or sprains more prevalent in females (45.5%, male 37.4%; p<0.001), males more frequently sustained fractures (26.3%, females 23.5%; p=0.017), wounds (17.1%, females 11.4%; p<0.001) & dislocations (5.2%, females 3.6%; p=0.006). Head injuries most prevalent in both genders (21%), but shoulder & chest injuries more common in males (15.1%, females 9.2%; p<0.001% & 6.8%, females 4.4%; p<0.001) & in females back (13.1%, males 10.2%; p<0.001%) & pelvis (4.2%, males 2.9%; p=0.009) injuries were more prevalent.
Sugimoto 2020 [83]; 19, 68% Moderate	Crossfit related injuries.	Chart review at Sports Medicine clinic 2003-16. N=115. 55 male, 24.4±10.8 yrs, 173.9±10.7 cm, 77.1±17.2 kg, 25.2±4.4 kg/m2. 60 female, 26.0±10.1 yrs, 164.8±7.6 cm, 65.7±14.4 kg, 24.3±5.4 kg/m2.	Injury proportion; upper extremity male 32.7%, female 21.7% (p<0.182), trunk/spine injury male 30.9%, female 20.0% (p<0.178). Lower extremity injury male 34.5% female 58.3% (p<0.011); female OR 2.65 (95%CI 1.25-5.65). Specific body parts/joints; knee male 23.6% female 30.0% (p<0.442), spine male 47.8% female 20.0% (p<0.257) hip/pelvis male 5.5% female 13.3% (p<0.151). Shoulder joint male 23.6% female 10.0% (p<0.049); male OR 2.79 (95%CI 0.98-7.95). When considering age; athletes aged <19 yrs & younger had greater trunk/spine CrossFit injury proportions (<19 yrs 37.5%, over 19 yrs 18.7%; p<0.027), OR 2.61 (95%CI 1.10-

			6.21). Athletes aged <19 yrs & younger had greater spinal CrossFit injury proportions (<19 yrs 37.5%, over 19 yrs 17.7%; p<0.027), OR 2.86 (95%CI 1.19-6.87). No sex analysis by age group. There were no statistically sig. BMI diff. between any injured & uninjured athletes.

ADOLESCENT

Chatha 2020 [153]; 12, 43% Limited	Concussion in football.	NEISS database. Concussion injuries occurring during football in paediatric patients (2-18 yrs old) from 2008-16. 3,285 injuries included 45% (1469) occurring in female players 49% (1617) in male players. Average age of the cohort was 13.5 yrs.	Based on national estimates, the football -related concussion rate was 2.51%/year. An average of 202 concussions occurred in male players each year & an average of 184 concussions in female players each year. No sig. sex diff. in overall prevalence or incidence.
Chun 2021 [154]; 18, 64% Moderate	Concussion in high school sports.	92,966 athletes from 63 schools. High school athletes. No further demographic information included. 2011-17.	6.4% all participants sustained a concussion. The pooled concussion rate for boys' sports was higher overall (1.00/1,000 AE, 95%CI 0.97-1.03) than for girls' sports (0.91/1,000 AE 95%CI 0.87-0.95) (p< 0.01). In sex matched sports girls had a higher rate of concussion than boys. Judo; boys 1.18 (95%CI 1.02-1.33), girls 1.92 (95%CI 1.68-2.17) (p< 0.01), football; boys 0.69 (95%CI 0.66-0.77), girls 1.10 (95%CI 1.01-1.19) (p< 0.01), basketball; boys 0.57 (95%CI 0.50-0.64), girls 1.09 (95%CI 0.98-1.19) (p< 0.01), & volleyball; boys 0.15 (95%CI 0.11-0.19), girls 0.54 (95%CI 0.47-0.60) (p< 0.01). The diff. in concussion rate between girls & boys participating in wrestling over the 6-year study period was not statistically sig. (P = 0.21).
Delaney 2014 [191]; 19, 68% Moderate	Concussion in American Football, ice hockey & football.	170; Female 47 (ice hockey 19, football 28, male 123 American Football 76, ice hockey 22, football 25). Mean age; American Football 21.1±1.1, ice hockey 21.3±1.0, football 20.5±1.2 yrs).	Sex diff. in injury mechanisms. In hockey; males more blow from an elbow (FE test p=0.02, Conversely, females more contact with the boards (FE test p=0.03). In football, females were more likely to suffer a concussion after contact with the ball (FE test p=0.02). No sig. sex diff. for injury mechanisms among different positions within the same sport. No sig. sex diff. for time lost. Across sport, males lost a median of 11 days (IQR, 7-18, females lost a median of 14 days (IQR, 10-21). In hockey, males lost median 10 days (IQR, 8-18, females lost a median of 14 days (IQR, 10-21). Football, males lost median 11 days (IQR, 7-21, females lost median 14 days (IQR, 10-21).
Deloes 1995 [86]; 15, 54% Moderate	Acute injury in ice hockey, basketball, handball, wrestling, hiking, alpine skiing, athletics,	16,120 injuries; 77% male (12,412). 14-20 yrs.	Sig. sex diff. across all sports; male 4.6/10,000 hrs & female 2.6. In sex comparable sports; male 4.9/10,000 hrs & female 3.2. Standardised for exposure; male 4.3/10,000 hrs & female 4.5. Sig. sex diff. in 5 sports; Basketball-female 4.9/10,000 hrs & male 3.5, Alpine Skiing-female 3.9 &

	fitness training, judo, football, alpinism, volleyball, apparatus gym.		male 3.0, Volleyball-female 3.8 & male 3.0, Apparatus Gymnastics-female 2.9 & male 1.5, Hiking-female 2.5 & male 3.6.
Forward 2014 [65]; 19, 68% Moderate	Acute injuries (assumed due to data from hospital database) in ice hockey.	Overall, 33,233; female=2,637 (7.9%) & male=30,596 (92.1%). Age 13.7±2.1yrs. Adolescent-Female 558 11-12yrs, 916 13-14yrs, 845 15-17yrs, total=2319. Male 6756 11-12yrs, 10,888 13-14yrs, 9435 15-17yrs, total=27,079. 12 females & 53 males left ED without being seen.	No sig. sex diff. for proportion of injured players overall. Top 3 injury types; female-soft tissue, sprain/strain & fracture, male-soft tissue, fracture & sprain/strain. Sig. sex diff. for proportion of soft tissue injuries; female 39.8%, male 32.6%. Sig. sex diff. for proportion of fractures; female 18.2%, male 27.1%. Sig. sex diff. for proportion of upper extremity injuries; female 39.2%, male 45.2%. Sig. sex diff. for proportion of injuries from checking; female 25.7%, male 42.8% & from falling; female 25.3%, male 14.8%. Admission to hospital in 2.6% female players, 3.1% males (p=0.18). Age specific break down of sig. sex diff.: Proportionately more soft tissue injuries in female players 11-12yrs (female 40%, male 34%, 13-14yrs (female 42%, male 32%, 15-17yrs (female 39%, male 31%). Proportionately more sprains/strain in female players 15-17yrs (female 26%, male 17%). Proportionately more fractures for male players 11-12yrs (female 22%, male 27%, 13-14yrs (female 17%, male 33%, 15-17yrs (female 16%, male 24%). No sig. sex diff. for concussion but pattern observed; male players even number across age grps with downward trend in older age. Female increased 11-17 with peak 13-14yrs.
Hoge 2020 [155]; 17, 61% Moderate	Wrestling injuries presenting to ED.	NEISS database 2005-19.	Annually, female patients presenting to US Eds increased sig. (p< 0.001) from 2005 (N = 1,500; 95%CI 923-2,078) to 2019 (N = 3,404; 95%CI 2,296-4,513). 50.1% (CI 44.1-56.2) of females sustaining wrestling-associated injuries were 14-18 yrs. Injury characteristics, including body parts affected & final diagnoses for patients 14-18 yrs of age, are stratified by patient gender. Males sustained greater proportions of head & neck injuries 24.6% (95%CI 23.2–26.0), female 18.5% (95%CI 13.2-23.9) (P = 0.018). Diagnoses: females sustained greater proportions of sprains & strains 48.8% (95%CI 41.2-56.3), males 34.4% (95%CI 31.6-37.1) (p< 0.001), no sex diff. by location of sprain/strain, shoulder most common in both female (17.1% [95%CI 12.8-21.5%]) & male (20.3% [95%CI 19.0-21.7]) wrestlers. Males sustained greater proportions of fractures 15.7% (CI 14.-

			16.7) females 10.6% (95%CI 7.5-13.7) (P = 0.003).
Hosea 2000 [43]; 16, 57% Moderate	Acute ankle Injuries in basketball.	6840 males (504 collegiate, 6336 scholastic players) 4940 females (364 collegiate & 4576 scholastic players).	Overall ankle injury, female RR 1.25. Grade I ankle sprains female RR 1.26 (p=0.0001). Collegiate ankle injuries female RR 1.33 (p=0.059). Scholastic ankle injuries female RR 1.24 (p=0.0006). The relative risk for an ankle injury doubled in both genders from scholastic to collegiate level, 2.19 for females & 2.05 for males. An injury was defined as a traumatic event suffered by the athlete that required evaluation & treatment by the athletic trainer, team physician, or both.
Honrado 2021 [156]; 14, 50% Moderate	Dance related injuries.	NEISS ED database 2014-18. N=4152 patients with a dance-related injury (83% female). 76% age 10-18yrs, 12.8% age 19-30yrs, 7.7% 31-60yrs, 3.3% 61+yrs.	The injuries occurred most commonly at the knee (22.5%; n = 935), ankle (15.7%; n = 650), & foot (10.2%; n = 424) & were diagnosed as sprain/strain (42.6%; n = 1767), fracture (10.3%; n = 428), & contusion (8.1%; n = 336). Diagnosis by body area, most common injuries were ankle sprain/strain (12.7%; n = 527), knee sprain/strain (10.4%; n = 431), & knee dislocation (4.3%; n = 179). Male patients had more fractures (13.6%, n = 94) than female patients (9.7%; n = 33.4), & male patients had fewer sprain/strains (34.9%; n = 242) than their female counterparts (44.1%; n= 1525). Overall IR female 12.4/100,000 people, male 3.0.
Khodaee 2020 [157]; 16, 57% Moderate	Acute lacrosse injuries.	NEISS ED database 1997-2015. Overall, 7,587 lacrosse-related injuries included. Males accounted for 75.5% injuries. The overall average age was 16.0±5.0 (range 5 to 71) yrs (males 16.1±5.2; females 15.7±4.1).	75% injuries were from males. Upper extremity injuries accounted for a larger proportion of injuries males than in females (IPR; 41.6% vs. 26.0%; p < 0.001). Lower extremity injuries accounted for a larger proportion of injuries in females than males (IPR; 34.7% vs. 21.9%; p < 0.001). Shoulder (including the clavicle) injuries accounted for a larger proportion of injuries in males than females (IPR; 12.3% vs 3.5%; p < 0.001). Females sustained larger percentage of knee (IPR; 10.5% vs 6.4%; p < 0.001) & ankle injuries (IPR; 17.0% vs 7.1%; p < 0.001) cf. to males, respectively. Females sustained a higher proportion of sprains/strains than males (IPR; 36% vs 21.9%; p < 0.01), males sustained a higher proportion of fractures (IPR; 21.3% vs. 10.8%, p < 0.01). Concussion diagnosis similar proportion between sexes (IPR; 6.1% male & 6.2% female; p > 0.05). There were also sex diff. in the rate of trunk injury (male 9.2%, female 7.2%; p<0.05), Head & neck injury (male 17.1%, female 19.2%; p<0.05) & face (male 10.2%, female 12.9%; p<0.05).

Owoeye 2020 [62]; 20, 71% Moderate	Acute & overuse injuries in basketball.	N= 518 players (16±1.4 yrs; 38.6% females), from 63 teams. N=200 females age 16±1.1 yrs (range: 13-18). N=318 males 16±1.5 yrs (range 11-18). Prospective cohort study. Players were observed through one competitive high school or club basketball season.	Overall IR 14.4 (99% CI 12.2-17.0) injuries/1000 h, female 13.8 (99% CI 11.2-16.8), male 14.8 (99.% CI 11.7-18.8); Female IRR 0.93 (95%CI 0.68-1.26). No sig. sex diff. in injury location, diagnoses or type. Trend towards higher incidence overuse injuries in male athletes 7.3 (99%CI 5.3-10.0), female 5.4 (99%CI 4.0-7.4) & higher incidence of acute injuries in female athletes 8.3 (99%CI 6.1-11.4), male 7.5 (99%CI 5.8-9.9). Trend towards higher incidence of acute (male 2.3 [99%CI 1.4-3.5], female 1.8 [99%CI 0.8-4.0]) & overuse (male 5.2 [99%CI 3.6-7.6], female 3.2 [2.1-4.9]) knee injuries in male athletes & a higher incidence of acute (female 4.7 [99%CI 3.3-6.7], male 3.7 [99%CI 2.8-6.7]) & overuse (female 1.5 [99%CI 0.8-2.7], male 1.3 [99%CI 0.8-2.2]) ankle injuries in female athletes.
Leppanen 2017 [192]; 17, 61% Moderate	Overuse injuries in basketball & floorball.	387 (male=211, female 176). 101 female basketball players; mean age 14.5±1.4yrs, height 168.4±6.6, weight 60.9±9.5kg, BMI 21.4±2.9, menarche onset=91. 100 male basketball players; mean age 15.2±1.6yrs, height 179.3±9.5, weight 68.9±13.2kg, BMI 21.3±3.1. 75 female floorball players; mean age 16.1±1.5yrs, height 166.5±5.6, weight 60.3±6.6kg, BMI 21.8±2.1, menarche onset=73. 111 male floorball players; mean age 16.9±1.3yrs, height 178.6±6.5, weight 70.1±8.7kg, BMI 22.0±2.3. 56 players dropped out across the 3 yrs.	Overall study IIR-1.51/1,000 hrs (95%CI 1.35-1.78). Most common knee IIR-0.54 (95%CI 0.42-0.67, lower back IIR-0.32 (95%CI 0.22-0.42). Sig. sex diff. for overall IIR-female 1.94 (95%CI 1.59-2.29, male 1.23 (95%CI 0.96-1.49). Foot IIR female-0.27 (95%CI 0.14-0.41, male 0.10 (95%CI 0.03-0.18). Shin/calf IIR female-0.24 (95%CI 0.12-0.37, male 0.03 (95%CI 0.00-0.07). Muscle/tendon injuries were most common amongst both sexes (56%). Female players sig. higher joint/ligament IIR-female-0.39 (95%CI 0.23-0.54, male 0.09 (95%CI 0.02-0.16). Overall female IRR=1.58 (95%CI 1.20-2.09). Foot injuries female IRR=2.69 (95%CI 1.14-6.94). Shin/calf injuries female IRR=8.30 (95%CI 2.17-53.62). Joint/ligament injuries female IRR=4.43 (95%CI 1.88-11.87). Basketball female IRR=1.61 (95%CI 1.07-2.46). Floorball female IRR=1.55 (95%CI 1.06-2.27). Injury classifications across the study; 44% all injuries were severe. 31% were moderate.
Pasanen 2018 [68]; 18, 64% Moderate	Acute injuries in floorball.	186 players (75 female, 111 male). F age 16.1±1.5) yrs, height 166.5±5.6)cm, weight 59.4(range 45.5-80.0)kg, BMI 21.5(range 17.8-27.2, Menarche, no/yes 2/73. M age 16.9±1.3)yrs height 177.5 (range 164.5-199)cm, weight 68.3 (range 52.4-98.5)kg. BMI 21.7(range 17.2-29.8).	Sig. sex diff. for overall IIR; female 2.40/1,000 hrs male 1.70, Game IIR; female 36.46/1,000 hrs male 19.42 & joint/ligament injury IRR; female 1.39/1,000 hrs, male 0.82. (Most common site of injury; ankle-37%, knee-18% & thigh-14%). Game (cf. to practice) IRR 21.21, (95%CI 15.30-29.82). Female overall IRR; 1.41 (95%CI 1.01-1.98). Female Game IRR; 1.88 (95%CI 1.12-3.19). Female joint/ligament IRR; 1.70 (95%CI 1.07-2.73).

Polites 2014 [69]; 18, 64% Moderate	Acute injuries in ice hockey.	168 injuries; female=26 (15%), male=142. Age <12=30(18%), 13-14=46(27%, 15-18=92(55%).	Sig. sex diff.; extremity injuries-male 50.7%, female 11.5%, TBI-male 16.9%, female 53.9% & spine injuries-male 9.2%, female 26.9%. Male players were most commonly injured by intentional contact (40.9%) & female players by unintentional contact (42.3%). Extremity injury male OR=7.89; (95%CI, 2.27-27.45). TBI female OR=5.46; (95%CI, 2.26-12.21). Female spine OR=3.66; (95%CI, 1.30-10.32).
Quatman 2009 [125]; 16, 57% Moderate	Acute & overuse injuries in weightlifting.	3,713 (3,102 male 611 female). Age 14-30. (High school injuries reported independently)	No sig. sex diff. in fracture injuries from strength training (p=0.37). Accident-related injuries female OR=1.69; (95%CI=1.37 to 2.08). Accidental foot injuries Female OR=2.44; (95%CI=1.75, 3.45). Accidental hand injuries male OR=2.14; (95%CI=1.49, 3.07). Trunk injuries male OR=1.55; (95%CI=1.25 to 1.96). Foot injury female OR=2.63; (95%CI=2.04 to 3.45). Leg injury female OR=1.54; (95%CI=1.05 to 2.22).
Reid 2012 [70]; 17, 61% Moderate	Acute & overuse injuries in track running.	4496; male 2012, female 2486. Age groups; 10-12yrs=770, 13-14yrs=1552, 15-18 yrs=2174	There was no sig. increase in the annual rate of track-related injuries over the study period (p=0.717). Elementary school age-Male laceration OR, 2.29 (95%CI, 1.49-3.52, male fractures/dislocations OR, 1.31 (95%CI, 1.07-1.60). Female sprain/strain OR, 1.32 (95%CI, 1.11-1.57). Elementary school age-Male trunk injury OR, 2.04; 95%CI, 1.65-2.53, male upper extremity OR, 1.30 (95%CI, 1.07-1.58). Female lower extremity OR, 1.63 (95%CI, 1.41-1.90). High school age-Male pelvic injury OR, 2.43; (95%CI, 1.92-3.07). Female ankle injury; OR, 1.80 (95%CI, 1.48-2.18).
Robinson 2014 [193]; 16, 57% Moderate	Acute & overuse shoulder injuries in American Football, football, basketball, wrestling, & baseball; volleyball, & softball.	2798 injuries. High school athletes. No demographic info included.	Shoulder injuries=8.4% all injuries over study period. Overall, Shoulder IIR across all sports 2.15/10,000AE's. No sig. sex diff. in the number of injuries requiring surgery; over 90% total sample did NOT require surgery. Over 40% male & 45% female athletes returned to sport within 1 wk. Boys basketball (10.6%), boys American Football (10.5%) & Girl's football (25.1%) resulted in >3wks medical disqualification. Across all sports, boys had double risk of injury during competition vs practice as cf. with girls (RR: 3.75 [95%CI: 3.46-4.05] vs 1.78 [95%CI:1.41-2.24]). In sex comparable sports competition as cf. with practice was equal (male RR: 2.68 [95%CI: 2.16-3.32] vs female RR 2.86 [95%CI: 2.17-3.78]). When comparing all 9 sampled sports; male fracture IPR=2.20 [95%CI: 1.05-4.59]. No sig. sex diff. in sex comparable sports only. Injury mechanism in all 9 sports; male contact with another person IPR=3.07 [95%CI: 2.35-4.01], female

			contact with the playing apparatus IPR=4.84 [95%CI: 2.77-8.48], female non-contact IPR=4.14 [95%CI: 3.32-5.16]. No sig. sex diff. in sex comparable sports.
Schallmo 2017 [126]; 19, 68% Moderate	Concussion in American Football, football , volleyball, basketball, wrestling, baseball, softball.	Injured student-athletes had a mean age (and standard deviation) of 15.9±1.2 yrs.	In sex-matched sports, girls IR sig. (p<0.05) higher than boys. During the 2005-2006 academic year, boys' American Football players (rate ratio, 3.26 [95%CI, 2.67 to 3.99]; p<0.0001) & girls' football players (rate ratio, 1.75 [95%CI, 1.30 to 2.34]; p=0.0002) demonstrated the highest concussion rates cf. with all other sports.
Sokka 2020 [63]; 19, 68% Moderate	Acute injuries in youth (9- to 14-year-old) football (football) players.	Ten football clubs. 730 players. 567 males 12.3±1.1 yrs, 151.7±10.0 cm, 41.2±8.7 kg, age at starting football 5.4±1.3 yrs; 163 females 12.4±1.1 yrs, 151.6±9.2 cm, 41.6±7.7 kg, age at starting football 6.7±1.5 yrs participated in 20-wks follow-up study (January–June 2015).	278 players sustained a total of 410 injuries: 22 % (n = 89) females, 78 % (n = 321) males. Overall IIR 6.47(95 % CI 5.84–7.01)/1000h football. 25.91(95%CI 22.41–29.40)/1000h football in games & 3.60 (95 %CI 3.10–4.10) in practices. Female overall IIR 7.20 (95 %CI 5.71–8.70), male 6.29 (95 %CI 5.60–6.98). Male IRR 0.86 (95%CI 0.64–1.17). Sex diff. in injury location: Ankle injuries, male 1.68, female 2.83, male IRR 0.58 (95%CI 0.35–0.96; p=0.033). Female ankle IRR 1.85 (95 %CI 1.18–2.91; p=0.007), female non-contact ankle injury rate IRR 2.78 (95%CI 1.91–4.02; p < 0.001). Shoulder injuries male 0.04, female 0.16, male IRR 0.24 (95%CI 0.09–0.65; p=.005).
Tsushima 2019 [72]; 20, 71% Moderate	Concussion in American Football, football, volleyball, basketball, wrestling/martial arts, baseball, softball, cheerleading, water polo, tennis, track & field & cross country.	5,938 males & 4,396 females, grades 8-12. 15.5 ±1.3 yrs. Participants 250 male & 262 female 13-year-olds, 1,295 male & 1,057 female 14-year-olds, 1,414 male and 1,063 female 15-year-olds, 1,456 male & 1,014 female 16-year-olds, 1,148 male & 796 female 17-year-olds, & 375 male & 204 female 18-year-olds.	In sports played by both sexes, girls had sig. higher concussion risks than boys in three comparable sports: basketball (14.8% vs. 9.1%, football (13.3% vs. 7.7%) & softball (12.8% vs. 6.5%). ARR for girls in all sports, including comparable sports, was 1.5 times greater than boys (ARR=1.50, p<0.0001). Female football RR=1.72 (CI=1.27, 2.32, p=0.0003. Female basketball RR 1.62 (CI=1.20, 2.19, p=0.0018. Softball RR 1.97 (CI=1.31, 2.97, p=0.0004.
Ursej 2019 [194]; 17, 61% Moderate	Acute & overuse injuries in hip hop dance.	Hip hop dancers from Slovenia (129, 114 females, 17.95±4.15 yrs).	Each dancer suffered 0.78 injuries (95%CI: 0.61-0.97) over 3 months. No sig sex diff. (F-0.76 [95%CI: 0.60-0.95] vs. M-0.93 [95%CI: 0.75-1.13]) (Mann-Whitney Z-value: 0.68, p=0.52). 3.12 injuries per dancer per year. 8.7 injuries/1000 hrs (95%CI: 6.9-1.1); M-10.33 (95%CI: 5.1-14.2, F-8.44 (95%CI: 3.5-15.1). Separating MSK-injuries (OSTRC scores >40) from MSK-problems (OSTRC: 1-40, 17% dancers suffered an MSK-injury, while an additional 33% reported MSK-problems, with no sig. sex diff. between (Chi square: 0.62, p=0.73). Injury that occurred during period of 6-months before study baseline was a strong predictor of MSK-injury & MSK-problem during study. Previous injury increased risk for occurrence of MSK-

			problem over the course of study by more than 2.5 times (OR: 2.62, 95%CI: 1.61-4.58, & risk for occurrence of MSK-injury by more than 3.5 times (OR: 3.76, 95%CI: 1.87-4.59).
Willick 2021 [161]; 16, 57% Moderate	MTB injuries.	Injury surveillance data from National Interscholastic Cycling Association (NICA) 2018 & 2019 seasons. Injuries tracked in 41,327 student-athlete-yrs, identifying 1,750 unique injuries during 1,155 injury events.	1,155 injury events in 41,327 student-athlete-yrs (79.7% male, 20.3% female), resulting in injury event proportion 2.8%. 1.52 unique injuries/injury event (1,750 unique injuries in 1,155 injury events). Injury event proportion higher in female riders than male riders (female 3.21%, male 2.69%; p=0.009). Sex diff. lower limb injury; 37.8% injuries female riders, 28.3% male riders (p=0.003).
Zynda 2022 [162]; 15, 54% Moderate	Basketball injuries.	NEISS database. 2012-18 patients aged 7-11 yrs (childhood) & 12-17 yrs (adolescence).	Females higher finger IIR (child female 13.8 [95%CI 10.5-17.1]/100,000 athlete days, male 8.0 [95%CI 6.4-9.6]; p=0.002) (adolescent female 17.4 [95%CI 14.3-20.5], male 11.5 [95%CI 9.1-13.9]; p=0.0032). Female higher rate of ankle strain/sprain IIR in child basketball players; 6.1 (95%CI 4.9-7.3), male 3.4 (95%CI 2.6-4.2), no sex-diff. in adolescents. No sex-based diff. in concussion or knee strain/sprain among childhood group; however, prevalence of each increased from childhood to adolescence, & the rate of increase for head injuries & knee injuries was sig. higher in female cf. with male athletes (p<0.0001 for both).

OR: odds ratio; aOR: adjusted odds ratio; CI: confidence interval; HR: hazard ratio; IRR: incidence rate ratio; RR: relative risk; IQR: interquartile range.

Table 8 Participant characteristics and main findings for the Tier-1 athlete studies.

Reference & Quality score	Focus	Participants characteristics, age (mean±SD)	Findings/comments
Meixner 2020 [163]; 15, 54% Moderate	Fractures & dislocations in sports & recreation.	NEISS-AIP data for 2005 to 2013. 18 sports & recreational activities in United States; American Football, baseball, basketball, softball, football, volleyball, ice hockey, ice skating, snow skiing, toboggan/sledding, inline skating, skateboarding, gymnastics, racquet sports, swimming, waterski/surfing, track & field, & combative sports.	Est total ED visit incidence 7.35/1000 people, 20.6% fractures, 3.6% dislocations. Annual ED visit incidence 1.51 fractures & 0.27 dislocations/1000 people. Sex diff. in fracture incidence overall, male OR 1.21 (95%CI 1.14-1.27), with bimodal peaks at 10 to 14 & >84 yrs. Highest incidence of fractures American Football (22.5%). Majority of fractures occurred in arm/hand (55.9%; 2,326,129). Sex diff. in dislocation incidence overall, male OR 1.50 (95%CI 1.38-1.62). Highest incidence of dislocations in basketball.
Stogner 2020 [164]; 17, 61% Moderate	Hand injuries in 42 different sports.	364 injuries - retrospective analysis. No other demographic info included. Sports categorised ball sports with a bat, ball sports without a bat, gymnastics, martial arts, climbing, outdoor sports, precision sports, cycling, equestrian sports, skating, water sports, winter sports & miscellaneous.	364 hand injuries, caused by 42 different types of sport. Highest prevalence in cycling (101, 28%), American Football (66, 18%) & equestrian sports (46, 13%). Highest prevalence category "ball sports without a bat" (114, 31%), cycling (101, 28%) & equestrian sports (46, 13%). Overall, males affected more often than females (118 females, 32%; 246 males, 68%). Sex diff. in equestrian sports, 84% (n=39) of equestrian-related hand injuries affected female study population (p< 0.001) & 33% equestrian sports accounted for most of female hand injuries. Sex diff. in ball sports without a bat (101 males, 89%; p< 0.001)*. *Due to American Football-associated injuries. No sex diff. for LOS or the need for operation respectively (p=0.306; p=0.703).
COMBINED ADOLESCENT & ADULT DATA			
Xiao 2022 [165]; 14, 50% Moderate	Nasal bone fractures in sports & recreation.	158,979 nasal fractures (25% female) over 10 yrs (2009-2018). Age 20.4 (SD12.3). Age groups; 0-12 (19.3%), 13-18 (36.2%), 18-65 (43%), >65 (1.5).	Ball sports account for 64% nasal bone fractures. Bicycles account for 5% the overall cohort. The most common causes of fracture in adults' basketball (n = 18 653, 26%) & in children baseball (n = 22 129, 25%). In males basketball accounted for highest proportion (25%) of nasal bone fractures, in females softball accounted for

			highest proportion (25%) of injuries. No further sex analysis.
Aman 2016 [84]; 19, 68% Moderate	Acute injury in motorcycle, handball, squash, floorball, hockey, golf.	Insurance company data. Mean number of licensed athletes was 1,162658 per year, 27% licensed athletes females. Mean±SD age for injured athletes in all sports during 4 yrs was 21.7±8.6 yrs. Mean age injured males 22.2±8.6 yrs & injured females 20.3±8.6 yrs.	Mean number of injuries 11,868 per year, 47,470 in total over 4 yrs. 10.2 injuries/1000athlete yrs. females 8.4, males 10.9. Female had sig. higher incidence of injury in; motorcycle (females 109.1, males 65), handball (females 71.1, males 57.2), Rugby (females 48, males 28.4), floorball (females 11.6, males 8.3), squash (females 28.6, males 3.4), golf (females 0.2, males 0.1). Male had sig. higher incidence of injury in ice hockey (females 29.4, males 48.7), basketball (females 5.0, males 6.1). Overall male RR 1.3. Among popular sports with high numbers of licensed athletes & with more than 200 injuries per year; automobile sports female RR 2.1, motorcycle female RR 1.7, floorball female RR 1.4, handball female RR 1.2). Ice hockey male RR 1.7 & basketball male RR 1.2.
Aman 2019 [85]; 15, 54% Moderate	Acute injury in ice hockey, floorball, handball, football.	Insurance company data. 92,162 registered injuries in total for all four sports (70,538 male injuries & 21,624 female injuries) during study 2006-2015, & in ice hockey (2006-2012). Males 21±7 yrs, females 19±6 yrs.	Highest IR (/1000 player yrs); Floorball female knee injury 4.8; Football female knee injury 7.8; Handball male hand/finger injury 9.4, male knee injury 10.5, female knee injury 20.7; Ice hockey male dental injury 9.3. Highest IR of concussion in Handball (male 1.3, female 2.0) & ice hockey (male 2.3, female 3.1). Females higher injury RR overall in floorball (1.4) & handball (1.1). Females higher RR for; knee injury in floorball (2.2), football (1.5) & handball (2.0), Cspine injury in floorball (1.9), football (1.9, handball (1.3) & ice hockey (1.3), SRC in floorball (2.1), football (1.2), handball (1.5) & ice hockey (1.3).

OR: odds ratio; aOR: adjusted odds ratio; CI: confidence interval; HR: hazard ratio; IRR: incidence rate ratio; RR: relative risk; IQR: interquartile range.

Figure 1. Flow diagram of identification, screening, eligibility and study inclusion of previously published studies.

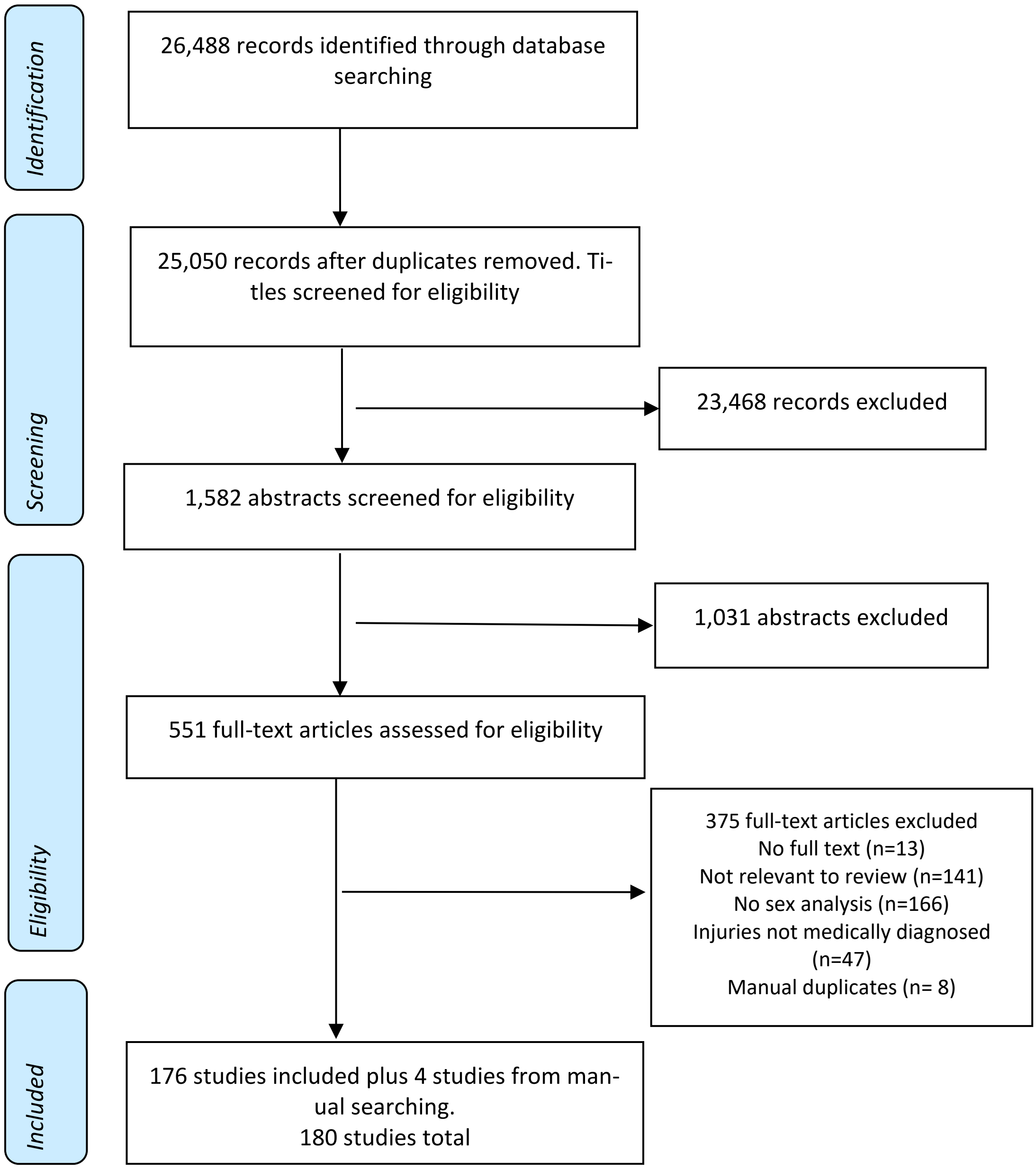


Figure 2. Meta-analysis for hamstring injuries in males

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Fixed, 95% CI	Year
Cross 2010 [89]	0.4824	0.1202	25.8%	1.62 [1.28, 2.05]	2010
Cross 2013 [90]	0.4947	0.0918	44.3%	1.64 [1.37, 1.96]	2013
Dalton 2015 [91]	0.3436	0.1961	9.7%	1.41 [0.96, 2.07]	2015
Edouard 2016 [38]	0.6627	0.1592	14.7%	1.94 [1.42, 2.65]	2016
Laruskain 2018 [167]	0.6575	0.2597	5.5%	1.93 [1.16, 3.21]	2018
Total (95% CI)			**100.0%**	**1.67 [1.48, 1.88]**	

Heterogeneity: Chi^2 = 2.04, df = 4 (P = 0.73); I^2 = 0%
Test for overall effect: Z = 8.36 (P < 0.00001)

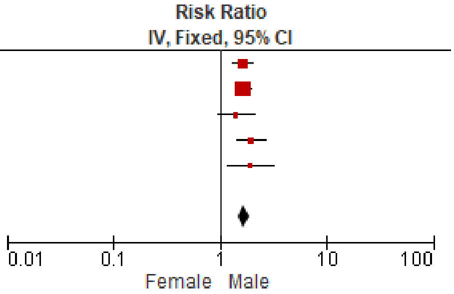


Figure 3. Meta-analysis for knee injuries in females

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Random, 95% CI	Year
Messina 1999 [180]	0.8329	0.1788	8.2%	2.30 [1.62, 3.27]	1999
Sallis 2000 [267]	1.3938	0.9154	0.6%	4.03 [0.67, 24.24]	2000
Swenson 2013 [128]	0.4187	0.0456	14.6%	1.52 [1.39, 1.66]	2013
Johansen 2015 [134]	1.0006	0.3574	3.4%	2.72 [1.35, 5.48]	2015
Mitchell 2015 [122]	0.5128	0.1729	8.5%	1.67 [1.19, 2.34]	2015
Fulstone 2016 [94]	0.27	0.062	14.0%	1.31 [1.16, 1.48]	2016
Mitchell 2016 [121]	0.7885	0.1024	12.0%	2.20 [1.80, 2.69]	2016
Traneus 2016 [170]	1.026	0.3166	4.1%	2.79 [1.50, 5.19]	2016
Roos 2017 [105]	0.4637	0.1351	10.3%	1.59 [1.22, 2.07]	2017
Gescheit 2017 [75]	-0.1165	0.7879	0.9%	0.89 [0.19, 4.17]	2017
Aman 2019 [85]	0.5306	0.5229	1.8%	1.70 [0.61, 4.74]	2019
Trojan 2019 [108]	0.2624	0.1061	11.8%	1.30 [1.06, 1.60]	2019
Trease 2020 [51]	0.0953	0.1625	8.9%	1.10 [0.80, 1.51]	2020
Owoeye 2020 [62]	-1.0788	0.7382	1.0%	0.34 [0.08, 1.44]	2020
Total (95% CI)			**100.0%**	**1.61 [1.39, 1.86]**	

Heterogeneity: Tau^2 = 0.04; Chi^2 = 42.78, df = 13 (P < 0.0001); I^2 = 70%
Test for overall effect: Z = 6.35 (P < 0.00001)

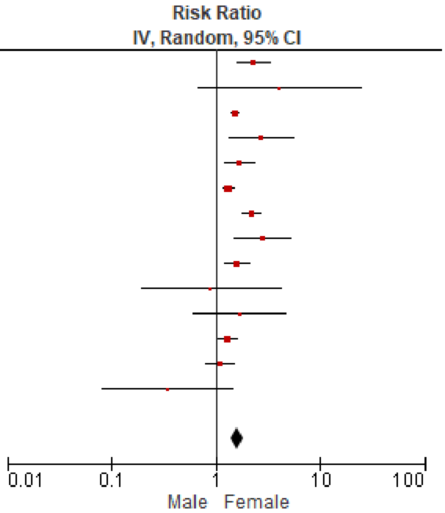


Figure 4. Meta-analysis for foot/ankle injuries in females

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Random, 95% CI	Year
Hosea 2000 [143]	0.2231	0.0574	19.2%	1.25 [1.12, 1.40]	2000
Hinton 2005 [136]	0.3148	0.1505	7.9%	1.37 [1.02, 1.84]	2005
Beynnon 2005 [64]	0.4121	0.3305	2.2%	1.51 [0.79, 2.89]	2005
Nelson 2007 [183]	0.0459	0.6161	0.7%	1.05 [0.31, 3.50]	2007
Swenson 2013 [128]	0.2231	0.0337	22.9%	1.25 [1.17, 1.34]	2013
Monfort 2015 [182]	0.4574	0.2283	4.2%	1.58 [1.01, 2.47]	2015
Westerman 2015 [110]	0.8629	0.9615	0.3%	2.37 [0.36, 15.60]	2015
Kerr 2016 [20]	-0.734	0.3328	2.2%	0.48 [0.25, 0.92]	2016
Kolstrup 2016 [67]	0.6259	0.6433	0.6%	1.87 [0.53, 6.60]	2016
Mauntel 2017 [101]	-0.5798	0.1591	7.3%	0.56 [0.41, 0.76]	2017
Tummala 2018 [109]	-0.2107	1.2209	0.2%	0.81 [0.07, 8.87]	2018
Aman 2019 [85]	-0.1393	0.8969	0.3%	0.87 [0.15, 5.05]	2019
Owoeye 2020 [62]	0.2151	0.8379	0.4%	1.24 [0.24, 6.41]	2020
Sokka 2020 [63]	0.6152	0.2294	4.1%	1.85 [1.18, 2.90]	2020
Fraser 2021 [145]	0.239	0.0081	25.3%	1.27 [1.25, 1.29]	2021
Willauschus 2021 [52]	-0.1508	0.378	1.7%	0.86 [0.41, 1.80]	2021
Zynda 2022 [162]	0.5822	0.6715	0.6%	1.79 [0.48, 6.67]	2022
Total (95% CI)			**100.0%**	**1.20 [1.09, 1.33]**	

Heterogeneity: Tau^2 = 0.01; Chi^2 = 41.86, df = 16 (P = 0.0004); I^2 = 62%
Test for overall effect: Z = 3.56 (P = 0.0004)

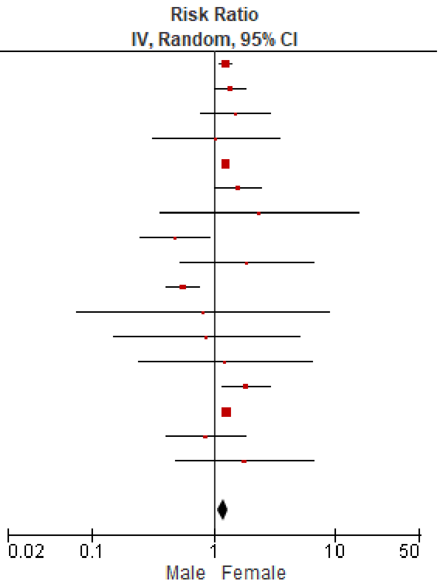


Figure 5. Meta-analysis for sport related concussion in females

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Fixed, 95% CI	Year
Hinton 2005 [136]	-0.5978	0.5991	0.1%	0.55 [0.17, 1.78]	2005
Gessel 2007 [95]	0.8329	0.2681	0.6%	2.30 [1.36, 3.89]	2007
Lincoln 2011 [119]	0.6419	0.1706	1.6%	1.90 [1.36, 2.65]	2011
Marar 2012 [120]	0.5306	0.0991	4.7%	1.70 [1.40, 2.06]	2012
Zuckerman 2015 [112]	0.7701	0.214	1.0%	2.16 [1.42, 3.29]	2015
Covassin 2016 [42]	0.4055	0.1181	3.3%	1.50 [1.19, 1.89]	2016
Roos 2017 [105]	0.5653	0.1468	2.2%	1.76 [1.32, 2.35]	2017
Kerr 2017 [66]	1.3164	0.5619	0.1%	3.73 [1.24, 11.22]	2017
O' Connor 2017 [184]	0.4447	0.0776	7.7%	1.56 [1.34, 1.82]	2017
Bretzin 2018 [196]	0.6419	0.0276	61.0%	1.90 [1.80, 2.01]	2018
Tsushima 2019 [72]	0.571	0.1734	1.5%	1.77 [1.26, 2.49]	2019
Bretzin 2021 [140]	0.6313	0.0544	15.7%	1.88 [1.69, 2.09]	2021
Vaandeering 2022 [61]	0.9632	0.6314	0.1%	2.62 [0.76, 9.03]	2022
Schroeder 2022 [152]	-1.1712	0.5286	0.2%	0.31 [0.11, 0.87]	2022
Total (95% CI)			**100.0%**	**1.84 [1.76, 1.92]**	

Heterogeneity: Chi² = 28.40, df = 13 (P = 0.008); I² = 54%
Test for overall effect: Z = 28.22 (P < 0.00001)

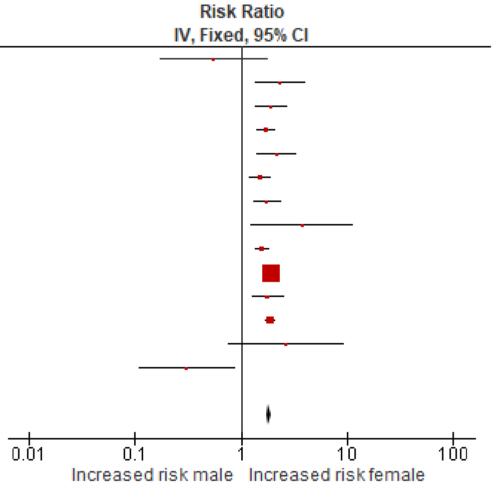


Figure 6. Meta-analysis for stress fractures in females

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Fixed, 95% CI	Year
Hame 2004 [166]	1.2149	0.2389	8.9%	3.37 [2.11, 5.38]	2004
Changstrom 2015 [115]	0.5596	0.1212	34.6%	1.75 [1.38, 2.22]	2015
Kerr 2016 [20]	0.207	2.9227	0.1%	1.23 [0.00, 378.19]	2016
Rizzone 2017 [104]	0.7227	0.095	56.4%	2.06 [1.71, 2.48]	2017
Total (95% CI)			**100.0%**	**2.03 [1.77, 2.34]**	

Heterogeneity: Chi² = 6.05, df = 3 (P = 0.11); I² = 50%
Test for overall effect: Z = 9.95 (P < 0.00001)

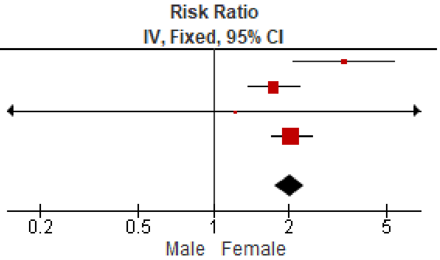
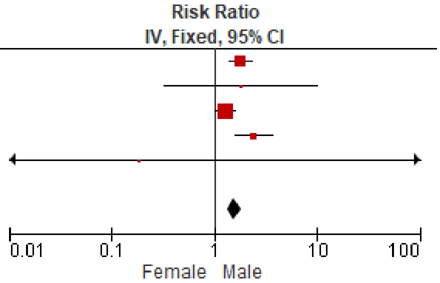


Figure 7. Meta-analysis for acute fractures in males

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Fixed, 95% CI	Year
Hame 2004 [166]	0.5878	0.1393	33.0%	1.80 [1.37, 2.37]	2004
Junge 2006 [32]	0.5933	0.8684	0.8%	1.81 [0.33, 9.93]	2006
Swenson 2010 [131]	0.2469	0.1109	52.0%	1.28 [1.03, 1.59]	2010
Swenson 2012 [130]	0.8671	0.2123	14.2%	2.38 [1.57, 3.61]	2012
Kerr 2016 [20]	-1.7037	7.708	0.0%	0.18 [0.00, 662451.35]	2016
Total (95% CI)			**100.0%**	**1.57 [1.34, 1.83]**	

Heterogeneity: Chi² = 8.30, df = 4 (P = 0.08); I² = 52%
Test for overall effect: Z = 5.63 (P < 0.00001)



Supplementary tables and figures

Supplementary Table S1. Modified Downs And Black Rating Questions For Methodological Quality Index Categorisation

See ST 1 DB questions.xls

Supplementary Table S2. Modified Downs and Black methodological quality index categorisation individual criteria scores for studies

See ST 2 DB individual ratings.xls

Supplementary Figure S1. Meta-analysis for hip/groin injuries in males

See SFA HipGroin Meta-analysis.pdf

Supplementary Figure S2. Meta-analysis for shoulder injuries in males

See SFB Shoulder Meta-analysis.pdf

References

References

1. Senne J. Examination of Gender Equity and Female Participation in Sport. *The Sport Journal* 2016; 24: 12.
2. Committee IO. IOC guidelines to ensure gender equal fair and inclusive representatioin in sport in Tokyo, https://olympics.com/ioc/news/new-ioc-guidelines-to-ensure-gender-equal-fair-and-inclusive-representation-in-sport-in-tokyo (2021, accessed 20 November 2021).
3. Editorial. The female ACL: Why is it more prone to injury? *Journal of Orthopaedics* 2016; 13. DOI: http://dx.doi.org/10.1016/S0972-978X(16)00023-4 0972-978X/.
4. Hewett TE, Myer, G.D, Ford, K.R, Paterno, M.V, Quatman, C.E. Mechanisms, Prediction, and Prevention of ACL Injuries: Cut Risk With Three Sharpened and Validated Tools. *Journal of Orthopedic Research* 2016; 34: 12.
5. Montalvo AM, Schneider, D.K, Webster, K.E, Yut, L, Galloway, M.T, Heidt, R.S, Kaeding, C.C, Kremcheck, T.E, Magnussen, R.A, Parikh, S.N, Stanfield, D.T, Wall, E.J, Myer, G.D. Anterior Cruciate Ligament Injury Risk in Sport: A Systematic Review and Meta-Analysis of Injury Incidence by Sex and Sport Classification. *Journal of Athletic Training* 2019; 54: 10.
6. Renstrom P, Ljungqvist, A, Arendt, E, Beynnon, B, Fukubayashi, T, Garrett, W, Georgoulis, T, Hewett, T.E, Johnson, R, Krosshaug, T, Mandelbaum, B, Micheli, L, Myklebust, G, Roos, E, Roos, H, Schamasch, P, Shultz, S, Werner, S, Wojtys, E, Engebretsen, L. Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement. *British Journal of Sport Medicine* 2008; 42: 18.
7. Shultz SJ, Schmitz, R.J, Cameron, K.L, Ford, K.R, Grooms, D.R, Lepley, L.K, Myer, G.D, Pietrosimone, B Anterior Cruciate Ligament Research Retreat VIII Summary Statement: An Update on Injury Risk Identification and Prevention Across the Anterior Cruciate Ligament Injury Continuum, March 14–16, 2019, Greensboro, NC. *Journal of Athletic Training* 2019; 54: 14.
8. Bruder AMC, K. M. Mosler, A. B. Patterson, B. Haberfield, M. Donaldson, A. Co-creation of a sport-specific anterior cruciate ligament injury risk reduction program for women: A concept mapping approach. *Journal of Science and Medicine in Sport* 2020; 23: 353-360. DOI: 10.1016/j.jsams.2019.10.019.
9. Myer GD, Sugimoto, D, Thomas, S, and Hewett, T.E. The Influence of Age on the Effectiveness of Neuromuscular Training to Reduce Anterior Cruciate Ligament Injury in Female Athletes: A Meta-Analysis. *The American Journal of Sports Medicine* 2013; 41: 12.
10. Wild CYS, J.R. and Munro, B.J. Why Do Girls Sustain More Anterior Cruciate Ligament Injuries Than Boys? A Review of the Changes in Estrogen and Musculoskeletal Structure and Function during Puberty. *Sports Medicine* 2012; 42: 16.
11. Bittencourt N.F.N, Meeuwisse W.H, Mendonça L.D, et al. Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition—narrative review and new concept. *British Journal of Sports Medicine* 2016; 50.
12. McKay A, Stellingwerff, T, Smith, E. et al. Defining Training and Performance Caliber: A Participant Classification Framework. *International Journal of Sports Physiology and Performance* 2022; 17: 14. DOI: https://doi.org/10.1123/ijspp.2021-0451.
13. Crossley KM, Patterson, B.E, Culvenor, A.G, Bruder, A.M, Mosler, A.B, Mentiplay, B.F. Making football safer for women: a systematic review and meta- analysis of injury prevention programmes in 11 773 female football (soccer) players. *British Journal of Sports Medicine* 2020; 54: 9.
14. Mentiplay BC, A. Mosler, A. Bruder, A. Patterson, B. Crossley, K. Injury risk reduction strategies for female football: systematic review and meta-analysis. *Journal of Science and Medicine in Sport* 2019; 22: S96-S97. DOI: 10.1016/j.jsams.2019.08.121.
15. Shultz SJ, Schmitz, R.J, Benjaminse, A, Chaudhari, A.M, Collins, Padua, D.A. ACL Resarch Retreat VI: An Update on ACL Injury Risk and Prevention. *Journal of Athletic Training* 2012; 47: 12.
16. Shultz SJ, Schmitz, R.J, Benjaminse, A, Collins, M, Ford, K.R, Kulas, A.S,. ACL Research Retreat VII: An Update Anterior Cruciate Ligament Injury Risk Factor Identification, Screening and Prevention. *Journal of Athletic Training* 2015; 50: 17.
17. Page M.J MJE, Bossuyt P.M, Boutron I, Hoffmann T.C, Mulrow C.D, et al. . The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ (OPEN ACCESS)* 2021;

372. DOI: doi: 10.1136/bmj.n71

18. Downs S.H aBN. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998; 52: 7.

19. Ryan R. Cochrane Consumers and Communication Group: meta-analysis. *Cochrane Consumers and Communication Group reviews: Meta-analysis*. Cochrane Consumers and Communication Review Group., 2016.

20. Kerr ZY, Kroshus E, Grant J, et al. Epidemiology of National Collegiate Athletic Association Men's and Women's Cross-Country Injuries, 2009-2010 Through 2013-2014. *Journal of Athletic Training (Allen Press)* 2016; 51: 57-64.

21. Allen N, Nevil A, Brooks J, et al. Ballet Injuries: Injury Incidence and Severity Over 1 Year. *Journal of Orthopaedic & Sports Physical Therapy* 2012; 42: 781-790. DOI: 10.2519/jospt.2012.3893.

22. Augustovicova D, Lystad RP and Arriaza R. Time-Loss Injuries in Karate: A Prospective Cohort Study of 4 Consecutive World Karate Championships. *Orthopaedic Journal of Sports Medicine* 2019; 7. DOI: 10.1177/2325967119865866.

23. Cierna D, Stefanovsky M, Matejova L, et al. Epidemiology of Competition Injuries in Elite European Judo Athletes: A Prospective Cohort Study. *Clinical Journal of Sport Medicine* 2017; 29: 336-340. DOI: 10.1097/jsm.0000000000000526.

24. Edouard P, Depiesse F, Branco P, et al. Analyses of Helsinki 2012 European Athletics Championships Injury and Illness Surveillance to Discuss Elite Athletes Risk Factors. *Clinical Journal of Sport Medicine* 2014; 24: 409-415. DOI: 10.1097/jsm.0000000000000052.

25. Edouard P, Feddermann-Demont N, Alonso JM, et al. Sex differences in injury during top-level international athletics championships: surveillance data from 14 championships between 2007 and 2014. *British Journal of Sports Medicine* 2015; 49: 472-U482. DOI: 10.1136/bjsports-2014-094316.

26. Edouard P, Steffen K, Junge A, et al. Gymnastics injury incidence during the 2008, 2012 and 2016 Olympic Games: analysis of prospectively collected surveillance data from 963 registered gymnasts during Olympic Games. *British Journal of Sports Medicine* 2018; 52: 475-+. DOI: 10.1136/bjsports-2017-097972.

27. Engebretsen L, Steffen K, Alonso JM, et al. Sports injuries and illnesses during the Winter Olympic Games 2010. *British Journal of Sports Medicine* 2010; 44: 772-780. DOI: 10.1136/bjsm.2010.076992.

28. Hagglund M, Walden M and Ekstrand J. Injuries among male and female elite football players. *Scandinavian Journal of Medicine & Science in Sports* 2009; 19: 819-827. DOI: 10.1111/j.1600-0838.2008.00861.x.

29. Hamid MSA, Puji A, Salleh Z, et al. Patterns of Injuries and Illness Among Malaysian Athletes during the XVII Asian Games 2014. *Sains Malaysiana* 2016; 45: 1531-1536.

30. Harringe ML, Renstrom P and Werner S. Injury incidence, mechanism and diagnosis in top-level teamgym: a prospective study conducted over one season. *Scandinavian Journal of Medicine & Science in Sports* 2007; 17: 115-119. DOI: 10.1111/j.1600-0838.2006.00546.x.

31. Hill T, Orchard J and Kountouris A. Incidence of Concussion and Head Impacts in Australian Elite-Level Male and Female Cricketers After Head Impact Protocol Modifications. *Sports Health-a Multidisciplinary Approach* 2019; 11: 180-185. DOI: 10.1177/1941738118811315.

32. Junge A, Langevoort G, Pipe A, et al. Injuries in team sport tournaments during the 2004 Olympic games. *American Journal of Sports Medicine* 2006; 34: 565-576. DOI: 10.1177/0363546505281807.

33. Moreno-Perez V, Hernandez-Sanchez S, Fernandez-Fernandez J, et al. Incidence and conditions of musculoskeletal injuries in elite Spanish tennis academies: a prospective study. *Journal of Sports Medicine and Physical Fitness* 2019; 59: 655-665. DOI: 10.23736/s0022-4707.18.08513-4.

34. Opar D, Drezner J, Shield A, et al. Acute Injuries in Track and Field Athletes A 3-Year Observational Study at the Penn Relays Carnival With Epidemiology and Medical Coverage Implications. *American Journal of Sports Medicine* 2015; 43: 816-822. DOI: 10.1177/0363546514562553.

35. Opar DA, Drezner J, Shield A, et al. Acute hamstring strain injury in track-and-field athletes: A 3-year observational study at the Penn Relay Carnival. *Scandinavian Journal of Medicine &*

Science in Sports 2014; 24: E254-E259. DOI: 10.1111/sms.12159.
36. Park KJ and Byung SB. Injuries in elite Korean fencers: an epidemiological study. *British Journal of Sports Medicine* 2017; 51: 220-225. DOI: 10.1136/bjsports-2016-096754.
37. Park KJ, Lee JH and Kim HC. Injuries in male and female elite Korean wrestling athletes: a 10-year epidemiological study. *British Journal of Sports Medicine* 2019; 53: 430-+. DOI: 10.1136/bjsports-2018-099644.
38. Edouard P, Branco P and Alonso JM. Muscle injury is the principal injury type and hamstring muscle injury is the first injury diagnosis during top-level international athletics championships between 2007 and 2015. *British Journal of Sports Medicine* 2016; 50: 619-U676. DOI: 10.1136/bjsports-2015-095559.
39. Hollander K, Wellmann K, zu Eulenburg C, et al. Epidemiology of injuries in outdoor and indoor hockey players over one season: a prospective cohort study. *British Journal of Sports Medicine* 2018; 52. DOI: 10.1136/bjsports-2017-098948.
40. Bere T, Kruczynski, J, Veintimilla, N, Hamu, Y, Bahr, R. Injury risk is low among world-class volleyball players: 4-year data from the FIVB Injury Surveillance System. *British Journal of Sports Medicine* 2015; 49: 1132-1137. DOI: 10.1136/bjsports-2015-094959.
41. Cierna D and Lystad RP. Epidemiology of competition injuries in youth karate athletes: a prospective cohort study. *British Journal of Sports Medicine* 2017; 51: 1285-+. DOI: 10.1136/bjsports-2017-097603.
42. Covassin T, Moran R and Elbin RJ. Sex Differences in Reported Concussion Injury Rates and Time Loss From Participation: An Update of the National Collegiate Athletic Association Injury Surveillance Program From 2004-2005 Through 2008-2009. *Journal of Athletic Training* 2016; 51: 189-194. DOI: 10.4085/1062-6050-51.3.05.
43. Hosea TM, Carey CC and Harrer MF. The gender issue: Epidemiology of ankle injuries in athletes who participate in basketball. *Clinical Orthopaedics and Related Research* 2000: 45-49.
44. Maciejewski R and Callanta H. Injuries and training variables in Filipino judo athletes. *Biomedical Human Kinetics* 2016; 8: 165-172. DOI: 10.1515/bhk-2016-0024.
45. Olsen OE, Myklebust G, Engebretsen L, et al. Injury pattern in youth team handball: a comparison of two prospective registration methods. *Scandinavian Journal of Medicine & Science in Sports* 2006; 16: 426-432. DOI: 10.1111/j.1600-0838.2005.00484.x.
46. Pieter W. Competition injury rates in young karate athletes. *Science & Sports* 2010; 25: 32-38. DOI: 10.1016/j.scispo.2009.07.001.
47. Powell JW and Barber-Foss KD. Sex-related injury patterns among selected high school sports. *American Journal of Sports Medicine* 2000; 28: 385-391.
48. Major DH, Steenstrup SE, Bere T, et al. Injury rate and injury pattern among elite World Cup snowboarders: a 6-year cohort study. *British Journal of Sports Medicine* 2014; 48: 18-+. DOI: 10.1136/bjsports-2013-092573.
49. Harris R, Trease L, Wilkie K, et al. Rib stress injuries in the 2012-2016 (Rio) Olympiad: a cohort study of 151 Australian Rowing Team athletes for 88 773 athlete days. *British journal of sports medicine* 2020; 54: 991-996. 2020/01/22. DOI: 10.1136/bjsports-2019-101584.
50. Kim HC and Ki Jun P. Injuries in Male and Female Elite Aquatic Sports Athletes: An 8-Year Prospective, Epidemiological Study. *Journal of sports science & medicine* 2020; 19: 390-396.
51. Trease L, Wilkie K, Lovell G, et al. Epidemiology of injury and illness in 153 Australian international-level rowers over eight international seasons. *British journal of sports medicine* 2020; 54: 1288-1293. DOI: https://dx.doi.org/10.1136/bjsports-2019-101402.
52. Willauschus M, Rüther J, Millrose M, et al. Foot and Ankle Injuries in Elite Taekwondo Athletes: A 4-Year Descriptive Analysis. *Orthopaedic journal of sports medicine* 2021; 9: 1-7. DOI: 10.1177/23259671211061112.
53. Abadi MR, Widyahening IS, Sudarsono NC, et al. Incidence Rate of Musculoskeletal Injuries among Professional Tennis Players during 2019 International Tournaments in Indonesia. *Journal of sports science & medicine* 2021; 20: 268-274. 2021/07/03. DOI: 10.52082/jssm.2021.268.
54. Chimera NJ, Merasty D and Lininger MR. Injuries and Illnesses Across 10 Years of Canada Games Competitions: 2009 -- 2019. *International journal of sports physical therapy* 2022; 17: 1372-1382.
55. Fröhlich S, Helbling M, Fucentese SF, et al. Injury risks among elite competitive alpine skiers are underestimated if not registered prospectively, over the entire season and regardless of whether requiring medical attention. *Knee surgery, sports traumatology, arthroscopy : official journal of the*

ESSKA 2021; 29: 1635-1643. 2020/06/20. DOI: 10.1007/s00167-020-06110-5.
56. Kim H-C and Park K-J. Type of injury and recovery time in elite adolescent Korean judo athletes: An epidemiological study. *International journal of sports science & coaching* 2021; 16: 682-689.
57. Mattiussi AM, Shaw JW, Williams S, et al. Injury epidemiology in professional ballet: a five-season prospective study of 1596 medical attention injuries and 543 time-loss injuries. *British journal of sports medicine* 2021; 55: 843-850. 2021/04/11. DOI: 10.1136/bjsports-2020-103817.
58. Vedung F, Hanni S, Tegner Y, et al. Concussion incidence and recovery in Swedish elite soccer - Prolonged recovery in female players. *Scandinavian journal of medicine & science in sports* 2020; 30: 947-957. DOI: https://dx.doi.org/10.1111/sms.13644.
59. Marchena-Rodriguez A, Gijon-Nogueron G, Cabello-Manrique D, et al. Incidence of injuries among amateur badminton players: A cross-sectional study. *Medicine* 2020; 99: e19785. DOI: https://dx.doi.org/10.1097/MD.0000000000019785.
60. O'Connor S, Huseyin OR, Whyte EF, et al. A 2-year prospective study of injuries and illness in an elite national junior tennis program. *The Physician and sportsmedicine* 2020; 48: 342-348. 2020/01/14. DOI: 10.1080/00913847.2020.1714512.
61. Vaandering K, Meeuwisse D, MacDonald K, et al. Injuries in Youth Volleyball Players at a National Championship: Incidence, Risk Factors, and Mechanisms of Injury. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine* 2022. DOI: https://dx.doi.org/10.1097/JSM.0000000000001098.
62. Owoeye OBA, Ghali B, Befus K, et al. Epidemiology of all-complaint injuries in youth basketball. *Scandinavian journal of medicine & science in sports* 2020; 30: 2466-2476.
63. Sokka T, Hilska M, Vasankari T, et al. Females Sustain more Ankle Injuries than Males in Youth Football. *International journal of sports medicine* 2020; 41: 1017-1023. 2020/07/21. DOI: 10.1055/a-1192-5399.
64. Beynnon BD, Vacek PM, Murphy D, et al. First-time inversion ankle ligament trauma: the effects of sex, level of competition, and sport on the incidence of injury. *American Journal of Sports Medicine* 2005; 33: 1485-1491.
65. Forward KE, Seabrook JA, Lynch T, et al. A comparison of the epidemiology of ice hockey injuries between male and female youth in Canada. *Paediatrics & Child Health* 2014; 19: 418-422. DOI: 10.1093/pch/19.8.418.
66. Kerr ZY, Cortes N, Caswell AM, et al. Concussion Rates in U.S. Middle School Athletes, 2015-2016 School Year. *American Journal of Preventive Medicine* 2017; 53: 914-918. DOI: 10.1016/j.amepre.2017.05.017.
67. Kolstrup LA, Koopmann KU, Nygaard UH, et al. Injuries during football tournaments in 45,000 children and adolescents. *European Journal of Sport Science* 2016; 16: 1167-1175. DOI: 10.1080/17461391.2016.1205145.
68. Pasanen K, Hietamo J, Vasankari T, et al. Acute injuries in Finnish junior floorball league players. *Journal of Science & Medicine in Sport* 2018; 21: 268-273. DOI: 10.1016/j.jsams.2017.06.021.
69. Polites SF, Sebastian AS, Habermann EB, et al. Youth Ice Hockey Injuries Over 16 Years at a Pediatric Trauma Center. *Pediatrics* 2014; 133: E1601-E1607. DOI: 10.1542/peds.2013-3628.
70. Reid JP, Nelson NG, Roberts KJ, et al. Track-related injuries in children and adolescents treated in US emergency departments from 1991 through 2008. *The Physician And Sportsmedicine* 2012; 40: 56-63. DOI: 10.3810/psm.2012.05.1965.
71. Stracciolini A, Casciano R, Levey Friedman H, et al. A Closer Look at Overuse Injuries in the Pediatric Athlete. *Clinical Journal of Sport Medicine* 2015; 25: 30-35.
72. Tsushima WT, Siu AM, Ahn HJ, et al. Incidence and Risk of Concussions in Youth Athletes: Comparisons of Age, Sex, Concussion History, Sport, and Football Position. *Archives of Clinical Neuropsychology* 2019; 34: 60-69. DOI: 10.1093/arclin/acy019.
73. Achenbach L, Loose O, Laver L, et al. Beach handball is safer than indoor team handball: injury rates during the 2017 European Beach Handball Championships. *Knee Surgery, Sports Traumatology, Arthroscopy* 2018; 26: 1909-1915. DOI: 10.1007/s00167-018-4907-5.
74. Fares MY, Fares J, Fares Y, et al. Musculoskeletal and head injuries in the Ultimate Fighting Championship (UFC). *Physician and Sportsmedicine* 2019; 47: 205-211. DOI: 10.1080/00913847.2018.1546108.
75. Gescheit DT, Cormack SJ, Duffield R, et al. Injury epidemiology of tennis players at the 2011-

2016 Australian Open Grand Slam. *British Journal of Sports Medicine* 2017; 51: 1289-1294. DOI: 10.1136/bjsports-2016-097283.
76. Kim KS, Park KJ, Lee J, et al. Injuries in national Olympic level judo athletes: an epidemiological study. *British Journal of Sports Medicine* 2015; 49: 1144-1150. DOI: 10.1136/bjsports-2014-094365.
77. Kirialanis P, Malliou P, Beneka A, et al. Injuries in artistic gymnastic elite adolescent male and female athletes. *Journal of Back and Musculoskeletal Rehabilitation* 2002; 16: 145-151. DOI: 10.3233/bmr-2002-16405.
78. McCurdie I, Smith S, Bell PH, et al. Tennis injury data from The Championships, Wimbledon, from 2003 to 2012. *British Journal of Sports Medicine* 2017; 51: 607-611. DOI: 10.1136/bjsports-2015-095552.
79. Toohey LA, Drew MK, Finch CF, et al. A 2-Year Prospective Study of Injury Epidemiology in Elite Australian Rugby Sevens: Exploration of Incidence Rates, Severity, Injury Type, and Subsequent Injury in Men and Women. *American Journal of Sports Medicine* 2019; 47: 1302-1311.
80. Jayanthi N, Kleithermes S, Dugas L, et al. Risk of Injuries Associated With Sport Specialization and Intense Training Patterns in Young Athletes: A Longitudinal Clinical Case-Control Study. *Orthopaedic journal of sports medicine* 2020; 8: 1-12. DOI: 10.1177/2325967120922764.
81. Gill SD, Stella J, Lowry N, et al. Gender differences in female and male Australian Football injuries - A prospective observational study of emergency department presentations. *Journal of science and medicine in sport* 2021; 24: 670-676. 2021/03/13. DOI: 10.1016/j.jsams.2021.02.011.
82. Hollander K, Johnson CD, Outerleys J, et al. Multifactorial Determinants of Running Injury Locations in 550 Injured Recreational Runners. *Medicine and science in sports and exercise* 2021; 53: 102-107. 2020/08/10. DOI: 10.1249/mss.0000000000002455.
83. Sugimoto D, Zwicker RL, Quinn BJ, et al. Part II: Comparison of Crossfit-Related Injury Presenting to Sports Medicine Clinic by Sex and Age. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine* 2020; 30: 251-256. 2019/12/17. DOI: 10.1097/jsm.0000000000000812.
84. Åman M, Forssblad M and Henriksson-Larsén K. Incidence and severity of reported acute sports injuries in 35 sports using insurance registry data. *Scandinavian Journal of Medicine & Science in Sports* 2016; 26: 451-462. DOI: 10.1111/sms.12462.
85. Åman M, Forssblad M and Larsén K. National injury prevention measures in team sports should focus on knee, head, and severe upper limb injuries. *Knee Surgery, Sports Traumatology, Arthroscopy* 2019; 27: 1000-1008. DOI: 10.1007/s00167-018-5225-7.
86. Deloes M. EPIDEMIOLOGY OF SPORTS INJURIES IN THE SWISS ORGANIZATION YOUTH-AND-SPORTS 1987-1989 - INJURIES, EXPOSURE AND RISKS OF MAIN DIAGNOSES. *International Journal of Sports Medicine* 1995; 16: 134-138. DOI: 10.1055/s-2007-972980.
87. Chandran A, Barron MJ, Westerman BJ, et al. Time Trends in Incidence and Severity of Injury Among Collegiate Soccer Players in the United States: NCAA Injury Surveillance System, 1990-1996 and 2004-2009. *American Journal of Sports Medicine* 2016; 44: 3237-3242. DOI: 10.1177/0363546516659879.
88. Covassin T, Swanik CB and Sachs ML. Sex differences and the incidence of concussions among collegiate athletes. *Journal of Athletic Training* 2003; 38: 238-244.
89. Cross KM, Gurka KK, Conaway M, et al. Hamstring Strain Incidence Between Genders and Sports in NCAA Athletics. *Athletic Training & Sports Health Care: The Journal for the Practicing Clinician* 2010; 2: 124-130.
90. Cross KM, Gurka KK, Saliba S, et al. Comparison of Hamstring Strain Injury Rates Between Male and Female Intercollegiate Soccer Athletes. *American Journal of Sports Medicine* 2013; 41: 742-748. DOI: 10.1177/0363546513475342.
91. Dalton SL, Kerr ZY and Dompier TP. Epidemiology of Hamstring Strains in 25 NCAA Sports in the 2009-2010 to 2013-2014 Academic Years. *American Journal of Sports Medicine* 2015; 43: 2671-2679. DOI: 10.1177/0363546515599631.
92. Eckard TG, Kerr ZY, Padua DA, et al. Epidemiology of Quadriceps Strains in National Collegiate Athletic Association Athletes, 2009-2010 Through 2014-2015. *Journal of Athletic Training* 2017; 52: 474-481. DOI: 10.4085/1062-6050-52.2.17.
93. Eckard TG, Padua DA, Dompier TP, et al. Epidemiology of Hip Flexor and Hip Adductor Strains in National Collegiate Athletic Association Athletes, 2009/2010-2014/2015. *American Journal of Sports Medicine* 2017; 45: 2713-2722. DOI: 10.1177/0363546517716179.

94. Fulstone D, Chandran A, Barron M, et al. Continued Sex-Differences in the Rate and Severity of Knee Injuries among Collegiate Soccer Players: The NCAA Injury Surveillance System, 2004-2009. *International Journal of Sports Medicine* 2016; 37: 1150-1153. Article. DOI: 10.1055/s-0042-112590.
95. Gessel LM, Fields SK, Collins CL, et al. Concussions among United States high school and collegiate athletes. *Journal of Athletic Training (National Athletic Trainers' Association)* 2007; 42: 495-503.
96. Hassebrock JD, Patel KA, Makovicka JL, et al. Lumbar Spine Injuries in National Collegiate Athletic Association Athletes: A 6-Season Epidemiological Study. *Orthopaedic Journal of Sports Medicine* 2019; 7. DOI: 10.1177/2325967118820046.
97. Hibberd EE, Kerr ZY, Roos KG, et al. Epidemiology of Acromioclavicular Joint Sprains in 25 National Collegiate Athletic Association Sports: 2009-2010 to 2014-2015 Academic Years. *American Journal of Sports Medicine* 2016; 44: 2667-2674. DOI: 10.1177/0363546516643721.
98. Hurtubise JM, Beech C and Macpherson A. Comparing Severe Injuries by Sex and Sport in Collegiate-Level Athletes: A Descriptive Epidemiologic Study. *International Journal of Athletic Therapy & Training* 2015; 20: 44-50. DOI: 10.1123/ijatt.2014-0090.
99. Kerbel YE, Smith CM, Prodromo JP, et al. Epidemiology of Hip and Groin Injuries in Collegiate Athletes in the United States. *Orthopaedic Journal of Sports Medicine* 2018; 6. DOI: 10.1177/2325967118771676.
100. Kerr ZY, Baugh CM, Hibberd EE, et al. Epidemiology of National Collegiate Athletic Association men's and women's swimming and diving injuries from 2009/2010 to 2013/2014. *British Journal of Sports Medicine* 2015; 49: 465-U474. DOI: 10.1136/bjsports-2014-094423.
101. Mauntel TC, Wikstrom EA, Roos KG, et al. The Epidemiology of High Ankle Sprains in National Collegiate Athletic Association Sports. *American Journal of Sports Medicine* 2017; 45: 2156-2163. DOI: 10.1177/0363546517701428.
102. Melvin PR, Souza S, Mead RN, et al. Epidemiology of Upper Extremity Injuries in NCAA Men's and Women's Ice Hockey. *American Journal of Sports Medicine* 2018; 46: 2521-2529. DOI: 10.1177/0363546518781338.
103. Owens BD, Agel J, Mountcastle SB, et al. Incidence of Glenohumeral Instability in Collegiate Athletics. *American Journal of Sports Medicine* 2009; 37: 1750-1754. DOI: 10.1177/0363546509334591.
104. Rizzone KH, Ackerman KE, Roos KG, et al. The Epidemiology of Stress Fractures in Collegiate Student-Athletes, 2004-2005 Through 2013-2014 Academic Years. *Journal of Athletic Training (Allen Press)* 2017; 52: 966-975.
105. Roos KG, Wasserman EB, Dalton SL, et al. Epidemiology of 3825 injuries sustained in six seasons of National Collegiate Athletic Association men's and women's soccer (2009/2010-2014/2015). *British Journal of Sports Medicine* 2017; 51: 1029-U1070. DOI: 10.1136/bjsports-2015-095718.
106. Sallis RE, Jones K, Sunshine S, et al. Comparing sports injuries in men and women. *International Journal of Sports Medicine* 2001; 22: 420-423. DOI: 10.1055/s-2001-16246.
107. Simmons MM, Swedler DI and Kerr ZY. Injury Surveillance of Head, Neck, and Facial Injuries in Collegiate Ice Hockey Players, 2009-2010 Through 2013-2014 Academic Years. *Journal of Athletic Training (Allen Press)* 2017; 52: 776-784.
108. Trojan JD, Treloar JA, Smith CM, et al. Epidemiological Patterns of Patellofemoral Injuries in Collegiate Athletes in the United States From 2009 to 2014. *Orthopaedic Journal of Sports Medicine* 2019; 7. DOI: 10.1177/2325967119840712.
109. Tummala SV, Hartigan DE, Makovicka JL, et al. 10-Year Epidemiology of Ankle Injuries in Men's and Women's Collegiate Basketball. *Orthopaedic Journal of Sports Medicine* 2018; 6. DOI: 10.1177/2325967118805400.
110. Westermann RW, Giblin M, Vaske A, et al. Evaluation of Men's and Women's Gymnastics Injuries: A 10-Year Observational Study. *Sports Health-a Multidisciplinary Approach* 2015; 7: 161-165. DOI: 10.1177/1941738114559705.
111. Wolf BR, Ebinger AE, Lawler MP, et al. Injury Patterns in Division I Collegiate Swimming. *American Journal of Sports Medicine* 2009; 37: 2037-2042. DOI: 10.1177/0363546509339364.
112. Zuckerman SL, Kerr ZY, Yengo-Kahn A, et al. Epidemiology of Sports-Related Concussion in NCAA Athletes From 2009-2010 to 2013-2014: Incidence, Recurrence, and Mechanisms. *American Journal of Sports Medicine* 2015; 43: 2654-2662. DOI: 10.1177/0363546515599634.

113. Zupon AB, Kerr ZY, Dalton SL, et al. The epidemiology of back/neck/spine injuries in National Collegiate Athletic Association men's and women's ice hockey, 2009/2010 to 2014/2015. *Research in Sports Medicine* 2018; 26: 13-26. DOI: 10.1080/15438627.2017.1365295.
114. Baugh CM and Kerr ZY. High School Rowing Injuries: National Athletic Treatment, Injury and Outcomes Network (NATION). *Journal of Athletic Training* 2016; 51: 317-320. DOI: 10.4085/1062-6050-51.4.13.
115. Changstrom BG, Brou L, Khodaee M, et al. Epidemiology of Stress Fracture Injuries Among US High School Athletes, 2005-2006 Through 2012-2013. *American Journal of Sports Medicine* 2015; 43: 26-33. DOI: 10.1177/0363546514562739.
116. Collins CL, Micheli LJ, Yard EE, et al. Injuries sustained by high school rugby players in the United States, 2005-2006. *Archives Of Pediatrics & Adolescent Medicine* 2008; 162: 49-54. DOI: 10.1001/archpediatrics.2007.1.
117. Frey A, Lambert C, Vesselle B, et al. Epidemiology of Judo-Related Injuries in 21 Seasons of Competitions in France: A Prospective Study of Relevant Traumatic Injuries. *Orthopaedic Journal of Sports Medicine* 2019; 7: N.PAG-N.PAG. DOI: 10.1177/2325967119847470.
118. Huffman EA, Yard EE, Fields SK, et al. Epidemiology of rare injuries and conditions among United States high school athletes during the 2005-2006 and 2006-2007 school years. *Journal of Athletic Training (National Athletic Trainers' Association)* 2008; 43: 624-630.
119. Lincoln AE, Caswell SV, Almquist JL, et al. Trends in Concussion Incidence in High School Sports A Prospective 11-Year Study. *American Journal of Sports Medicine* 2011; 39: 958-963. DOI: 10.1177/0363546510392326.
120. Marar M, McIlvain NM, Fields SK, et al. Epidemiology of Concussions Among United States High School Athletes in 20 Sports. *American Journal of Sports Medicine* 2012; 40: 747-755. DOI: 10.1177/0363546511435626.
121. Mitchell J, Graham W, Best TM, et al. Epidemiology of meniscal injuries in US high school athletes between 2007 and 2013. *Knee Surgery Sports Traumatology Arthroscopy* 2016; 24: 715-722. DOI: 10.1007/s00167-015-3814-2.
122. Mitchell J, Magnussen RA, Collins CL, et al. Epidemiology of Patellofemoral Instability Injuries Among High School Athletes in the United States. *American Journal of Sports Medicine* 2015; 43: 1676-1682. DOI: 10.1177/0363546515577786.
123. Muller L, Hildebrandt C, Muller E, et al. Injuries and illnesses in a cohort of elite youth alpine ski racers and the influence of biological maturity and relative age: a two-season prospective study. *Open Access Journal of Sports Medicine* 2017; 8: 113-122. DOI: 10.2147/oajsm.S133811.
124. Pierpoint LA, Williams CM, Fields SK, et al. Epidemiology of Injuries in United States High School Track and Field: 2008-2009 Through 2013-2014. *American Journal of Sports Medicine* 2016; 44: 1463-1468. DOI: 10.1177/0363546516629950.
125. Quatman CE, Myer GD, Khoury J, et al. SEX DIFFERENCES IN "WEIGHTLIFTING" INJURIES PRESENTING TO UNITED STATES EMERGENCY ROOMS. *Journal of Strength and Conditioning Research* 2009; 23: 2061-2067. DOI: 10.1519/JSC.0b013e3181b86cb9.
126. Schallmo MS, Weiner JA and Hsu WK. Sport and Sex-Specific Reporting Trends in the Epidemiology of Concussions Sustained by High School Athletes. *Journal of Bone & Joint Surgery, American Volume* 2017; 99: 1314-1320. DOI: 10.2106/JBJS.16.01573.
127. Schroeder AN, Comstock RD, Collins CL, et al. Epidemiology of Overuse Injuries among High-School Athletes in the United States. *Journal of Pediatrics* 2015; 166: 600-606. DOI: 10.1016/j.jpeds.2014.09.037.
128. Swenson DM, Collins CL, Best TM, et al. Epidemiology of Knee Injuries among U.S. High School Athletes, 2005/2006-2010/2011. *Medicine and Science in Sports and Exercise* 2013; 45: 462-469. DOI: 10.1249/MSS.0b013e318277acca.
129. Swenson DM, Collins CL, Fields SK, et al. Epidemiology of US High School Sports-Related Ligamentous Ankle Injuries, 2005/06-2010/11. *Clinical Journal of Sport Medicine* 2013; 23: 190-196. DOI: 10.1097/JSM.0b013e31827d21fe.
130. Swenson DM, Henke NM, Collins CL, et al. Epidemiology of United States High School Sports-Related Fractures, 2008-09 to 2010-11. *American Journal of Sports Medicine* 2012; 40: 2078-2084. DOI: 10.1177/0363546512453304.
131. Swenson DM, Yard EE, Collins CL, et al. Epidemiology of US High School Sports-Related Fractures, 2005-2009. *Clinical Journal of Sport Medicine* 2010; 20: 293-299. DOI: 10.1097/JSM.0b013e3181e8fae8.

132. Swenson DM, Yard EE, Fields SK, et al. Patterns of Recurrent Injuries Among US High School Athletes, 2005-2008. *American Journal of Sports Medicine* 2009; 37: 1586-1593. DOI: 10.1177/0363546509332500.
133. Yard EE, Schroeder MJ, Fields SK, et al. The epidemiology of United States high school soccer injuries, 2005-2007. *American Journal of Sports Medicine* 2008; 36: 1930-1937.
134. Johansen MW, Steenstrup SE, Bere T, et al. Injuries in World Cup telemark skiing: a 5-year cohort study. *British Journal of Sports Medicine* 2015; 49: 453-457. DOI: 10.1136/bjsports-2014-094211.
135. Steenstrup SE, Bere T and Bahr R. Head injuries among FIS World Cup alpine and freestyle skiers and snowboarders: a 7-year cohort study. *British Journal of Sports Medicine* 2014; 48: 41-45. DOI: 10.1136/bjsports-2013-093145.
136. Hinton RY, Lincoln AE, Almquist JL, et al. Epidemiology of lacrosse injuries in high school-aged girls and boys - A 3-year prospective study. *American Journal of Sports Medicine* 2005; 33: 1305-1314. DOI: 10.1177/0363546504274148.
137. Hunt KJ, Hurwit D, Robell K, et al. Incidence and Epidemiology of Foot and Ankle Injuries in Elite Collegiate Athletes. *American Journal of Sports Medicine* 2017; 45: 426-433. DOI: 10.1177/0363546516666815.
138. Mertz KC, Bolia IK, English MG, et al. Epidemiology and Outcomes of Maxillofacial Injuries in NCAA Division I Athletes Participating in 13 Sports. *Orthopaedic journal of sports medicine* 2022; 10: 1-6. DOI: 10.1177/23259671221083577.
139. Belilos E, Jow S and Maxwell M. Descriptive Epidemiology of High School Swimming and Diving Injuries. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine* 2023. DOI: https://dx.doi.org/10.1097/JSM.0000000000001121.
140. Bretzin AC, Covassin T, Wiebe DJ, et al. Association of Sex With Adolescent Soccer Concussion Incidence and Characteristics. *JAMA network open* 2021; 4: e218191. 2021/04/28. DOI: 10.1001/jamanetworkopen.2021.8191.
141. Chan JJ, Geller JS, Chen KK, et al. Epidemiology of Severe Foot Injuries in US Collegiate Athletes. *Orthopaedic journal of sports medicine* 2021; 9: 1-7. DOI: 10.1177/23259671211001131.
142. Comeau AK, Parent EC and Kennedy MD. Do Female University Varsity Athletes Have a Greater Risk of Injury Within a Competitive Varsity Season? *International journal of exercise science* 2023; 16: 129-147.
143. Deckey DG, Makovicka JL, Chung AS, et al. Neck and Cervical Spine Injuries in National College Athletic Association Athletes: A 5-Year Epidemiologic Study. *Spine* 2020; 45: 55-64. DOI: https://dx.doi.org/10.1097/BRS.0000000000003220.
144. Deckey DG, Scott KL, Hinckley NB, et al. Hand and Wrist Injuries in Men's and Women's National Collegiate Athletic Association Basketball. *Orthopaedic journal of sports medicine* 2020; 8: 1-8. DOI: 10.1177/2325967120953070.
145. Fraser JJ, MacGregor AJ, Ryans CP, et al. Sex and occupation are salient factors associated with lateral ankle sprain risk in military tactical athletes. *Journal of science and medicine in sport* 2021; 24: 677-682. 2021/03/13. DOI: 10.1016/j.jsams.2021.02.016.
146. Haines C, Jensen HK, Karim SA, et al. Analysis of Injuries in Competitive Equestrian Events. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine* 2022; 32: e508-e512. DOI: https://dx.doi.org/10.1097/JSM.0000000000001004.
147. Hopkins C, Kanny S and Headley C. The Problem of Recurrent Injuries in Collegiate Track and Field. *International journal of sports physical therapy* 2022; 17: 643-647.
148. Lacasse D and Njororai WWS. Season-long pattern and anatomical distribution of injuries among college soccer players. *Journal of Physical Education & Sport* 2021; 21: 927-933.
149. Lievers WB, Goggins KA and Adamic P. Epidemiology of Foot Injuries Using National Collegiate Athletic Association Data From the 2009-2010 Through 2014-2015 Seasons. *Journal of athletic training* 2020; 55: 181-187. 2020/01/03. DOI: 10.4085/1062-6050-560-18.
150. Marshall AN, McLeod TCV and Lam KC. Characteristics of Injuries Occurring During Cross-Country: A Report from the Athletic Training Practice-Based Research Network. *Journal of Athletic Training (Allen Press)* 2020; 55: 1230-1238.
151. Post EG, Simon JE, Robison H, et al. Epidemiology of Overuse Injuries in US Secondary School Athletics From 2014–2015 to 2018–2019 Using the National Athletic Treatment, Injury and Outcomes Network Surveillance Program. *Journal of Athletic Training (Allen Press)* 2022; 57: 510-516.

152. Schroeder GG, McClintick DJ, Trikha R, et al. Injuries Affecting Intercollegiate Water Polo Athletes: A Descriptive Epidemiologic Study. *Orthopaedic journal of sports medicine* 2022; 10: 1-10. DOI: 10.1177/23259671221110208.
153. Chatha K, Pruis T, Fernandez Peaguda C, et al. Concussions in Soccer: An Epidemiological Analysis in the Pediatric Population. *Orthopaedic journal of sports medicine* 2020; 8: 1-5. DOI: 10.1177/2325967120951077.
154. Chun BJ, Furutani T, Oshiro R, et al. Concussion Epidemiology in Youth Sports: Sports Study of a Statewide High School Sports Program. *Sports health* 2021; 13: 18-24. 2020/07/28. DOI: 10.1177/1941738120932570.
155. Hoge C, Pirruccio K, Cohen OG, et al. Rising Trends in Wrestling-associated Injuries in Females Presenting to US Emergency Departments. *The western journal of emergency medicine* 2020; 22: 410-416. 2021/04/16. DOI: 10.5811/westjem.2020.9.48490.
156. Honrado J, Bay RC and Lam KC. Epidemiology of Patients with Dance-Related Injuries Presenting to Emergency Departments in the United States, 2014-2018. *Sports health* 2021; 13: 471-475. 2021/02/09. DOI: 10.1177/1941738120984113.
157. Khodaee M, Kirk K, Pierpoint LA, et al. Epidemiology of lacrosse injuries treated at the United States emergency departments between 1997 and 2015. *Research in sports medicine (Print)* 2020; 28: 426-436. 2020/01/29. DOI: 10.1080/15438627.2020.1721499.
158. Mintz JJ, Jones CMC, Seplaki CL, et al. Track and field injuries resulting in emergency department visits from 2004 to 2015: an analysis of the national electronic injury surveillance system. *The Physician and sportsmedicine* 2021; 49: 74-80. 2020/06/09. DOI: 10.1080/00913847.2020.1779001.
159. Morrissey PJ, Maier Ii SP, Zhou JJ, et al. Epidemiology and trends of adult ice hockey injuries presenting to United States emergency departments: A ten-year analysis from 2007–2016. *Journal of orthopaedics* 2020; 22: 231-236. DOI: 10.1016/j.jor.2020.04.015.
160. Rugg CD, Malzacher T, Ausserer J, et al. Gender differences in snowboarding accidents in Austria: a 2005-2018 registry analysis. *BMJ open* 2021; 11: e053413. 2021/10/21. DOI: 10.1136/bmjopen-2021-053413.
161. Willick SE, Ehn M, Teramoto M, et al. The National Interscholastic Cycling Association Mountain Biking Injury Surveillance System: 40,000 Student-Athlete-Years of Data. *Current sports medicine reports* 2021; 20: 291-297. 2021/06/09. DOI: 10.1249/jsr.0000000000000850.
162. Zynda AJ, Wagner Iii KJ, Liu J, et al. Epidemiology of Pediatric Basketball Injuries Presenting to Emergency Departments: Sex- and Age-Based Patterns. *Orthopaedic journal of sports medicine* 2022; 10: 1-7. DOI: 10.1177/23259671211066503.
163. Meixner Cory and R.T. L. The Demographics of Fractures and Dislocations Across the Entire United States due to Common Sports and Recreational Activities. *Sports Health: A Multidisciplinary Approach* 2020; 12: 159-169.
164. A. SV, Kaltenborn Alexander, Laser Hans, et al. Hand injuries in sports - a retrospective analysis of 364 cases. *BMC musculoskeletal disorders* 2020; 21: 826. DOI: https://dx.doi.org/10.1186/s12891-020-03807-z.
165. Xiao C.C, Kshirsagar R.S, Hoerter J.E, et al. Sport and Recreational Causes of Nasal Bone Fractures. *Annals of Otology, Rhinology & Laryngology* 2022; 131: 760-766. DOI: 10.1177/00034894211042446.
166. Hame SL, LaFemina JM, McAllister DR, et al. Fractures in the collegiate athlete. *American Journal of Sports Medicine* 2004; 32: 446-451. DOI: 10.1177/0363546503261708.
167. Larruskain J, Lekue JA, Diaz N, et al. A comparison of injuries in elite male and female football players: A five-season prospective study. *Scandinavian Journal of Medicine & Science in Sports* 2018; 28: 237-245.
168. Neidel P, Wolfram P, Hotfiel T, et al. Cross-Sectional Investigation of Stress Fractures in German Elite Triathletes. *Sports* 2019; 7. DOI: 10.3390/sports7040088.
169. Owoeye OBA, Aiyegbusi AI, Fapojuwo OA, et al. Injuries in male and female semi-professional football (soccer) players in Nigeria: prospective study of a National Tournament. *BMC Research Notes* 2017; 10: 133-133. DOI: 10.1186/s13104-017-2451-x.
170. Tranaeus U, Gotesson E and Werner S. Injury Profile in Swedish Elite Floorball: A Prospective Cohort Study of 12 Teams. *Sports Health-a Multidisciplinary Approach* 2016; 8: 224-229. DOI: 10.1177/1941738116628472.
171. Yang JZ, Tibbetts AS, Covassin T, et al. Epidemiology of Overuse and Acute Injuries Among

Competitive Collegiate Athletes. *Journal of Athletic Training* 2012; 47: 198-204.
172. Darrow CJ, Collins CL, Yard EE, et al. Epidemiology of Severe Injuries Among United States High School Athletes 2005-2007. *American Journal of Sports Medicine* 2009; 37: 1798-1805. DOI: 10.1177/0363546509333015.
173. Fernandez WG, Yard EE and Comstock RD. Epidemiology of lower extremity injuries among U.S. high school athletes. *Academic Emergency Medicine* 2007; 14: 641-645.
174. Harmer PA. Incidence and characteristics of time-loss injuries in competitive fencing: a prospective, 5-year study of national competitions. *Clinical Journal of Sport Medicine* 2008; 18: 137-142.
175. Kerr ZY, Collins CL, Fields SK, et al. Epidemiology of Player-Player Contact Injuries Among US High School Athletes, 2005-2009. *Clinical Pediatrics* 2011; 50: 594-603. DOI: 10.1177/0009922810390513.
176. Kerr ZY, Collins CL, Pommering TL, et al. Dislocation/Separation Injuries Among US High School Athletes in 9 Selected Sports: 2005-2009. *Clinical Journal of Sport Medicine* 2011; 21: 101-108. DOI: 10.1097/JSM.0b013e31820bd1b6.
177. Kerr ZY, Lincoln AE, Dodge T, et al. Epidemiology of Youth Boys' and Girls' Lacrosse Injuries in the 2015 to 2016 Seasons. *Medicine & Science in Sports & Exercise* 2018; 50: 284-291. DOI: 10.1249/MSS.0000000000001422.
178. Kronisch RL, Pfeiffer RP, Chow TK, et al. Gender differences in acute mountain bike racing injuries. *Clinical Journal of Sport Medicine* 2002; 12: 158-164.
179. Lanzi JT, Chandler PJ, Cameron KL, et al. Epidemiology of Posterior Glenohumeral Instability in a Young Athletic Population. *American Journal of Sports Medicine* 2017; 45: 3315-3321. DOI: 10.1177/0363546517725067.
180. Messina DF, Farney WC and DeLee JC. The incidence of injury in Texas high school basketball - A prospective study among male and female athletes. *American Journal of Sports Medicine* 1999; 27: 294-299. DOI: 10.1177/03635465990270030401.
181. Miyake E, Yatsunami, M, Kurabayashi, J, Teruya, K, Sekine, Y, Endo, T, Nishida, R, Takano, N, Sato, S, Kyung, H.J. A Prospective Epidemiological Study of Injuries in Japanese National Tournament-Level Badminton Players From Junior High School to University. *Asian Journal of Sports Medicine* 2016; 7: 1-6.
182. Monfort SM, Comstock RD, Collins CL, et al. Association Between Ball-Handling Versus Defending Actions and Acute Noncontact Lower Extremity Injuries in High School Basketball and Soccer. *American Journal of Sports Medicine* 2015; 43: 802-807. DOI: 10.1177/0363546514564541.
183. Nelson AJ, Collins CL, Yard EE, et al. Ankle injuries among United States high school sports athletes, 2005-2006. *Journal of Athletic Training (National Athletic Trainers' Association)* 2007; 42: 381-387.
184. O'Connor KL, Baker MM, Dalton SL, et al. Epidemiology of Sport-Related Concussions in High School Athletes: National Athletic Treatment, Injury and Outcomes Network (NATION), 2011-2012 Through 2013-2014. *Journal of Athletic Training* 2017; 52: 175-185. DOI: 10.4085/1062-6050-52.1.15.
185. Pytiak AV, Kraeutler MJ, Currie DW, et al. An Epidemiological Comparison of Elbow Injuries Among United States High School Baseball and Softball Players, 2005-2006 Through 2014-2015. *Sports Health: A Multidisciplinary Approach* 2018; 10: 119-124. DOI: 10.1177/1941738117736493.
186. Rauh MJ, Margherita AJ, Rice SG, et al. High school cross country running injuries: A longitudinal study. *Clinical Journal of Sport Medicine* 2000; 10: 110-116. DOI: 10.1097/00042752-200004000-00005.
187. Roos KG, Marshall SW, Kerr ZY, et al. Epidemiology of Overuse Injuries in Collegiate and High School Athletics in the United States. *American Journal of Sports Medicine* 2015; 43: 1790-1797.
188. Stracciolini A, Casciano R, Friedman HL, et al. Pediatric Sports Injuries A Comparison of Males Versus Females. *American Journal of Sports Medicine* 2014; 42: 965-972. DOI: 10.1177/0363546514522393.
189. Tirabassi J, Brou L, Khodaee M, et al. Epidemiology of High School Sports-Related Injuries Resulting in Medical Disqualification 2005-2006 Through 2013-2014 Academic Years. *American Journal of Sports Medicine* 2016; 44: 2925-2932. DOI: 10.1177/0363546516644604.
190. Dane S, Can S, Gursoy R, et al. Sport injuries: Relations to sex, sport, injured body region. *Perceptual and Motor Skills* 2004; 98: 519-524. Article.

191. Delaney JS, Al-Kashmiri A and Correa JA. Mechanisms of Injury for Concussions in University Football, Ice Hockey, and Soccer. *Clinical Journal of Sport Medicine* 2014; 24: 233-237. DOI: 10.1097/jsm.0000000000000017.
192. Leppanen M, Pasanen K, Kannus P, et al. Epidemiology of Overuse Injuries in Youth Team Sports: A 3-year Prospective Study. *International Journal of Sports Medicine* 2017; 38: 847-856. DOI: 10.1055/s-0043-114864.
193. Robinson TW, Corlette J, Collins CL, et al. Shoulder Injuries Among US High School Athletes, 2005/2006-2011/2012. *Pediatrics* 2014; 133: 272-279. DOI: 10.1542/peds.2013-2279.
194. Ursej E, Sekulic D, Prus D, et al. Investigating the Prevalence and Predictors of Injury Occurrence in Competitive Hip Hop Dancers: Prospective Analysis. *International Journal of Environmental Research and Public Health* 2019; 16. DOI: 10.3390/ijerph16173214.
195. Edouard PB, P. Alonso, JM. Muscle injury is the principal injury type and hamstring muscle injury is the first injury diagnosis during top-level international athletics championships between 2007 and 2015. *Br J Sports Med* 2016: 13. DOI: doi:10.1136/ bjsports-2015-095559.
196. Bretzin AC, Covassin T, Fox ME, et al. Sex Differences in the Clinical Incidence of Concussions, Missed School Days, and Time Loss in High School Student-Athletes: Part 1. *American Journal of Sports Medicine* 2018; 46: 2263-2269. DOI: 10.1177/0363546518778251.
197. Borowski LA, Yard EE, Fields SK, et al. The epidemiology of US high school basketball injuries, 2005-2007. *American Journal of Sports Medicine* 2008; 36: 2328-2335.
198. Ackerman K.E, Stellingwerff T, ElliottSale K.J, et al. #REDS (Relative Energy Deficiency in Sport): time for a revolution in sports culture and systems to improve athlete health and performance. *British Journal of Sport Medicine* 2020; 0: 2. DOI: 10.1136/bjsports-2019-101926.
199. Parsons JL, Coen, S.E. and Bekker, S. Anterior cruciate ligament injury: towards a gendered environmental approach. *British Journal of Sport Medicine* 2021; 55: 6.
200. Schofield KL, Thorpe, H, Sims, S.T. Compartmentalised disciplines: Why low energy availability research calls for transdicsiplinary approaches. *Performance Enhancement and Health* 2020. DOI: https://doi.org/10.1016/j.peh.2020.100172.
201. Thorpe H. Athletic Women's Experiences of Amenorrhea: Biomedical Technologies, Somatic Ethics and Embodied Subjectivities. *Sociology of Sport Journal* 2016; 33: 13. DOI: https://doi.org/10.1123/ssj.2015-0030.
202. Gilhooly M CR, O' Sullivan K, Norton, C. A systematic literature review of injury epidemiology and surveillance practices in elite adult female field-based team sport. *Journal of Science and Medicine in Sport* 2023; 26: 7.
203. Almousa S, Mullen, R, Williams, K, et al. Identification of potential risk factors for lower limb injuries in female team-sport athletes: a prospective cohort study. *Science and Medicine in Football* 2023: 12. DOI: https://doi.org/10.1080/24733938.2023.2181386.
204. Collings TJ, Bourne, M.N., Barrett, R.S. et al. . Risk Factors for Lower Limb Injury in Female Team Field and Court Sports: A Systematic Review, Meta-analysis, and Best Evidence Synthesis. *Sports Med* 2021; 51: 7. DOI: https://doi.org/10.1007/s40279-020-01410-9.
205. Mason J ea. Intrinsic Risk Factors for Ankle Sprain Differ Between Male and Female Athletes: A Systematic Review and Meta-Analysis. *Sports Medicine - Open* 2022; 8: 14. DOI: https://doi.org/10.1186/s40798-022-00530-y.
206. Hewett TE, Myer, G. D., & Ford, K. R. . The influence of growth and pubertal maturation on neuromuscular performance in high-risk female athletes. Medicine and Science in Sports and Exercise. *Medicine and Science in Sports and Exercise, 34(5), Supplement abstract 1384* 2002; 34.
207. Zech A, et al. Sex differences in injury rates in team-sport athletes: A systematic review and meta-regression analysis. *Journal of Sport and Health Science* 2022; 11: 10.
208. Ekstrand Jea. Hamstring injury rates have increased during recent seasons and now constitute 24% of all injuries in men's professional football: the UEFA Elite Club Injury Study from 2001/02 to 2021/22. *British Journal of Sports Medicine* 2023; 57: 6.
209. Ristolainen L, Heinonen A, Waller B, et al. Gender differences in sport injury risk and types of injuries: a retrospective twelve-month study on cross-country skiers, swimmers, long-distance runners and soccer players. *Journal of Sports Science and Medicine* 2009; 8: 443-451.
210. Danielsson A HA, Senorski C, et al. The mechanism of hamstring injuries – a systematic review. *BMC Musculoskelet Disord* 2020; 21. DOI: doi: 10.1186/s12891-020-03658-8.
211. Freckleton GaP, T. Risk factors for hamstring muscle strain injury in sport: a systematic review and meta-analysis. *Br J Sports Med* 2013; 47: 7. DOI: doi:10.1136/bjsports-2011-090664.

212. Grenn B, Bourne, M, van Dyk, N et al. Recalibrating the risk of hamstring strain injury (HSI): A 2020 systematic review and meta- analysis of risk factors for index and recurrent hamstring strain injury in sport. *Br J Sports Med* 2020; 54: 7. DOI: doi:10.1136/bjsports-2019-100983.
213. Martin R, et al. Hamstring Strain Injury in Athletes. *J Orthop Sports Phys Ther* 2022; 52: 44. DOI: 10.2519/jospt.2022.0301.
214. Orchard J. Men at higher risk of groin injuries in elite team sports: a systematic review. *Br J Sports Med* 2015; 49: 4. DOI: doi: 10.1136/bjsports-2014-094272.
215. Walden M, Hagglund M, and Ekstrand, J. The epidemiology of groin injury in senior football. *British Journal of Sports Medicine* 2015; 49: 30.
216. Schache AG, et al. Anatomical and morphological characteristics may explain why groin pain is more common in male than female athletes. *Br J Sports Med* 206. DOI: 10.1136/bjsports-2016-096945.
217. Schilders E. Groin injuries in athletes. *Curr Orthop* 2000; 14: 5.
218. Haroy JT, K. Serner, A. Bjorkheim, A. Rolstad, L.E. Holmich, P. Bahr, R. Andersen, T.E. Including the Copenhagen Adduction Exercise in the FIFA 11+ Provides Missing Eccentric Hip Adduction Strength Effect in Male Soccer Players. A Randomised Controlled Trial. *The American Journal of Sports Medicine* 2017; 45: 7.
219. Benson Street SaK, T. Does the FIFA 11+ Program Prevent Hamstring Injuries in College-Aged Male Soccer Players? A Critically Appraised Topic. *Journal of Sport Rehabilitation* 2021; 30: 2.
220. Cuchna JW, Welsch, L, Meier, T, Regelski, C.L. and Van Lunen, B. The Effectiveness of Nordic Hamstring Exercises in Reducing Hamstring Injuries in Competitive Soccer Players: A Critically Appraised Topic. *International Journal of Athletic Therapy and Training* 2017; 22: 5.
221. Bel LM, N. Ducrest, V. Bizzini, M. Lower Limb Exercise Based Injury Prevention Programs Are Effective in Improving Speed, Jumping, Agility and Balance: an Umbrella Review. *International Journal of Sports Physical Therapy* 2021; 16: 8.
222. Petushek EJS, D. Stoolmiller, M. Smith, G. Myer, G.D. Evidence-Based Best-Practice Guidleines for Preventing Anterior Cruciate Ligament Injuries in Young Female Athletes. *American Journal of Sports Medicine* 2019; 47: 9.
223. Yoo JHL, B. O. Ha, M. Lee, S. W. Oh, S. J. Lee, Y. S. et al. . A meta-analysis of the effect of neuromuscular training on the prevention of the anterior cruciate ligament injury in female athletes. . *Knee Surgery, Sports Traumatology, Arthroscopy* 2010; 18: 6. DOI: 10.1007/s00167-009-0901-2.
224. Myer GDS, D. Thomas, S. and Hewett, T. E. The influence of age on the effectiveness of neuromuscular training to reduce anterior cruciate ligament injury in female athletes: a meta-analysis. *American Journal of Sports Medicine* 2013; 41: 12. DOI: 10.1177/0363546512460637.
225. Schwank A BP, Asker M, et al. 2022 Bern Consensus statement on Soulder injury Prevention, Rehabilitation, and Return to Sport for Athletes at All Particiaption Levels. *Journal of Orthopaedic and Sports Physical Therapy* 2022; 52: 17.
226. Sogi Y, Hagiwara, Y, Yabe, Y et al. Association between trunk pain and lower extremity pain among youth soccer players: a cross-sectional study. *BMC Sports Science, Medicine and Rehabilitation* 2018; 10: 7. DOI: https://doi.org/10.1186/s13102-018-0102-8.
227. Emami M, Mohseni Bandpei, MA, Rahmani, N et al. Association between trunk muscles characteristics with lower limb injuries: A systematic review. *Physical Therpay in Sport* 2018; 32: 6. DOI: https://doi.org/10.1016/j.ptsp.2018.04.013.
228. Silva Barros B, Silva Cavalcanti, IB, et al. Correlation between upper limb function and clinical measures of shoulder and trunk mobility and strength in overhead athletes with shoulder pain. *Physical Therapy in Sport* 2022; 55: 8. DOI: https://doi.org/10.1016/j.ptsp.2022.02.001.
229. Sciascia AaC, R. Review Article Kinetic Chain Rehabilitation: A Theoretical Framework. *Rehabilitation Research and Practice* 2012; 2012: 9. DOI: doi:10.1155/2012/853037.
230. Cowan S, Schache, G, Brukner, P et al. Delayed Onset of Transversus Abdominus in Long-Standing Groin Pain. *Medicine and Science in Sport and Exercise* 2004; 36: 5. DOI: 10.1249/01.mss.0000147587.81762.44.
231. Schuermans J, Danneels, L, Van Tiggelen, D, et al. Proximal Neuromuscular Control Protects Against Hamstring Injuries in Male Soccer Players: A Prospective Study With Electromyography Time-Series Analysis During Maximal Sprinting. *Am J Sports Med* 2017; 45: 10.

DOI: 10.1177/0363546516687750. Epub 2017 Mar 1.
232. Botta A, Waiteman, MC, Ozores Perez, V et al. Trunk muscle endurance in individuals with and without patellofemoral pain: Sex differences and correlations with performance tests. *Physical Therpay in Sport* 2021; 52: 7. DOI: https://doi.org/10.1016/j.ptsp.2021.09.012.
233. Deering R, Senefeld, W, Pashibin, T et al. Muscle function and fatigability of trunk flexors in males and females. *Biology of sex differences* 2017; 8: 12. DOI: 10.1186/s13293-017-0133-y.
234. Deadato M, Saponaro, S, Simunic, A, et al Sex-based comparison of trunk flexors and extensors functional and contractile characteristics in young gymnasts. *Sport Sciences for Health* 2023. DOI: https://doi.org/10.1007/s11332-023-01083-7.
235. Duffy DE-S, K.J. Gardner, H. Goldstein, S. Wideman, L. Endocrine Responses to Sport-Related Brain Injury in Female Athletes: A Narrative Review and a Call for Action. *Endocrines* 2021; 2: 9.
236. McGroarty N, Brown S and Mulcahey M. Sport-related concussion in female athletes: A systematic review. *Orthop J Sports Med* 2020; **8**. DOI: 10.1177/2325967120932306.
237. Covassin TE, R.J. . The female athlete: the role of gender in the assessment and management of sport-related concussion. . *Clinics in Sports Medicine* 2011; 1: 6.
238. Wallace JC, T. Beidler, E. Sex differences in high school athletes' knowledge of sport-related concussion symptoms and reporting behaviors. *Journal of Athletic Training* 2017; 52: 6.
239. Zuckerman SLA, R.P. Odom, M.J. Effect of sex on symptoms and return to baseline in sport related concussion. *Journal of Neurosurgery: Pediatrics* 2014; 13: 9.
240. Tierney RTS, M.R. Swanik, C.B. Swanik, et al. Gender differences in head-neck segment dynamic stabilization during head acceleration. . *Medicine and Science in Sports and Exercise* 2005; 37(2):272–279.: 7.
241. McGroaty NKB, S.M. Mulcahey, M.K. Sport Related Concussion in Female Athletes. *The Orthopaedic Journal of Sport Medicine* 2020; 8. DOI: 10.1177/2325967120932306.
242. Dolle JP, Jaye, A. Anderson, S. et al. Newfound sex differences in axonal structure underlie differential outcomes form in vitro traumatic axonal injury. Experimental neurology *Experimental neurology* 2018; 30: 13.
243. Davis DPD, D.J. Smith, W. et al. . Traumatic Brian Injury Outcomes in pre and post menopausal females versus age matched males. . *Journal of Neurotrauma* 2006: 8.
244. Wunderle K, Hoeger, K.M, Wasserman, E., Bazarian, J., Menstrual Phase as Predictor of Outcome After mild Traumatic Brain Injury in Women. Journal of Head Trauma Rehabilitation, 2014. 26(5): p. 7. Menstrual Phase as Predictor of Outcome After mild Traumatic Brain Injury in Women. . *Journal of Head Trauma Rehabilitation* 2014; 26.
245. Snook MLH, L.C. Sanfilippo, J.S. et al Association of concussion with abnormal menstrual patterns in adolescent and young women. . *Journal of the American Medical Association Pediatrics* 2017; 171: 7.
246. Chace K, Bachmann, G., Simonds, A., & Dettwiler, A. Does Oral Contraceptive Use Lessen the Impact of Concussions in Adult Female Athletes? . *Obstetrics & Gynecology* 2017; 129. DOI: 10.1097/01.aog.0000514101.56654.2210.1097/01.AOG.0000514101.566.
247. Lopez Jr V, Ma R, Weinstein MG, et al. Concussive Injuries in Rugby 7s: An American Experience and Current Review. *Medicine & Science in Sports & Exercise* 2016; 48: 1320-1330. DOI: 10.1249/MSS.0000000000000892.
248. D'Lauro C JE, Swope LMC, et al. . Under- representation of female athletes in research informing influential concussion consensus and position statements: an evidence review and synthesis. *Br J Sports Med 2022;56:981–987* 2022: 6. DOI: doi:10.1136/bjsports-2021-105045.
249. Hollander K ea. Sex-Specific Differences in Running Injuries: A Systematic Review with Meta-Analysis and Meta-Regression. *Sports Medicine* 2021; 51: 28.
250. De Souza M, Nattiv, A, Joy, E, et al. Female Athlete Triad Coalition Consensus Statement on Treatment and Return to Play of the Female Athlete Triad. *Br J Sports Med* 2014; 48. DOI: doi:10.1136/bjsports-2013-093218.
251. Mountjoy MS-B, J.K. Burke, L.M. et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *British Journal of Sport Medicine* 2018; 52: 10.
252. Min S-KO, T. Hyun Kim, S. et al. Position Statement: Exercise Gudielines to Increase Peak Bone Mass in Adolescents. *Journal fo Bone Metabolism* 2019; 26: 14.
253. Papageorgiou MD, E. Elliott-Sale, K.J. Sale, C. Reduced energy availability: implicaitons for bone health in physically active populations. *European Journal of Nutrition* 2018; 57: 12.

254. Hutson MJOD, E. Brooke-Wavell, K. Sale, C. Blagrove, R.C. Effects of Low Energy Availability on Bone Health in Endurance Athletes and High Impact Exercsie as A Potential Countermeasure: A Narrative Review. *Sports Medicine* 2021; 51: 12.

255. Nichols DS, C. Love, A. Resistance training and bone mineral density in adolescent females. *Journal of Pediatrics* 2001; 139: 6.

256. Zhao RZ, M. Xu, Z. . The effects of differing resistance training modes on the preservation of bone mineral density in postmenopausal women: a meta-analysis. . *Osteoporos International* 2015; 26: 13.

257. Martyn-St James MC, S. . Progressive high-intensity resistance training and bone mineral density changes among premenopausal women: evidence of discordant site-specific skeletal effects. . *Sports Medicine* 2006; 36: 21.

258. von Stengel SK, W. Kalender, WA. Engelke, K. Lauber, D. Differential effects of strength versus power training on bone mineral density in postmenopausal women: a 2-year longitudinal study. *British Journal of Sport Medicine* 2007; 41: 6.

259. Aicale R, Tarantino D and Maffuli N. Overuse injuries in sport: a comprehensive overview. *Journal of Orthopaedic Surgery and Research* 2018; 13: 11.

260. Dos'Santos T SG, Morse C, et al. Effects of the menstrual cycle phase on anterior cruciate ligament neuromuscular and biomechanical injury risk surrogates in eumenorrheic and naturally menstruating women: A systematic review. . *PLoS ONE* 2023; 18. DOI: https://doi.org/10.1371/journal.pone.0280800.

261. Martínez-Fortuny NA-C, A.; Da Cuña-Carrera, I, et al. Menstrual Cycle and Sport Injuries: A Systematic Review. *Int J Environ Res Public Health* 2023; 20. DOI: 10.3390/ijerph20043264.

262. Martin D TK, Cowie C, Alty J, Mehta R, et al. Injury Incidence Across the Menstrual Cycle in International Footballers. *Front Sports Act Living* 2021; 3. DOI: 10.3389/fspor.2021.616999.

263. Bahr R, Clarsen B, Derman W, et al. International Olympic Committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020 (including STROBE Extension for Sport Injury and Illness Surveillance (STROBE- SIIS)). *British Journal of Sport Medicine* 2020; 54: 17.

264. Moore I, Crossley, KM, Bo, K, et al. Female athlete health domains: a supplement to the International Olympic Committee consensus statement on methods for recording and reporting epidemiological data on injury and illness in sport. *Br J Sports Med* 2023; Epub ahead of print: accessed 02 July 2023. DOI: 10.1136/ bjsports-2022-106620.

265. Cierna D, Barrientos M, Agrasar C, et al. Epidemiology of injuries in juniors participating in top-level karate competition: a prospective cohort study. *British Journal of Sports Medicine* 2018; 52: 730-734. DOI: 10.1136/bjsports-2017-097756.

266. Beis K, Pieter W and Abatzides G. Taekwondo techniques and competition characteristics involved in time-loss injuries. *Journal of Sports Science and Medicine* 2007; 6: 45-51.

267. Sallis JF, Prochaska JJ and Taylor WC. A review of correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise* 2000; 32: 963-975.

268. Yang J, Tibbetts AS, Covassin T, et al. Epidemiology of Overuse and Acute Injuries Among Competitive Collegiate Athletes. *Journal of Athletic Training (National Athletic Trainers' Association)* 2012; 47: 198-204.