# Injury Rates and Characteristics Associated with Participation in Organized Dance Education: A Systematic Review

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## Abstract

**Introduction** Several studies and recent systematic reviews have investigated injury in dance settings that have largely focused on specific concert dance genres (i.e., ballet, contemporary) and/or elite levels (i.e., pre-professional, professional) of dance. Less is known about the health of those who participate in dance education settings, namely teachers and students from private dance studios. Given these individuals constitute a large proportion of the dance community, greater clarity of risks in the dance training environment could benefit an underserved majority by informing the development of effective injury prevention strategies.

**Objective** The primary objective was to describe injury rates and characteristics associated with participation in organized dance education settings.

**Methods** Six electronic databases were searched to April 2021 (Medline, EMBASE, SportDiscus, CINAHL, SCOPUS, Cochrane). Selected studies met a priori inclusion criteria that required original data from dance teacher/student samples within formal dance education

settings. All genres of dance were eligible. Studies were excluded if no injury outcomes or estimates of dance exposure were reported, if injuries occurred during rehearsal/performance, or if dance was used as a therapeutic intervention/exercise. Two reviewers independently assessed each paper for inclusion at abstract and full text screening stages. Quality of included studies was assessed using the Joanna Briggs Institute Level of Evidence tool.

**Results** The initial database search identified 1,424 potentially relevant records, 26 were included and scored. Most studies (n=22) focused on dance students only, three included only dance teachers, and one study included both. Among both dance students and teachers, the majority of injuries reported were overuse/chronic and involved the lower limb. For studies that reported injury rates (n=14), estimates ranged from 0.8-4.7 injuries/1000 dance hours, 4.86/1000 dancer-days, and 0.21-0.34/1000 dance exposures.

**Conclusions** Based on the current research, dance students and teachers experience a similar rate of injury, most commonly overuse lower extremity injuries. There have been few high-quality investigations of injury specific to the dance training environment. Therefore, consensus around the burden of injury in the dance education settings remains difficult. Future dance epidemiological investigations that examine the burden of injury among dance teachers and students, include operational injury and exposure definitions, and utilize prospective designs are warranted.

**Key Words:** Dance injuries, epidemiology, dance education, dance students, dance teachers

**Key Points:**

**1.** In the dance education setting, dance students, and teachers experience a similar rate of injury, most commonly overuse lower extremity injuries.

**2.** Dance teachers are greatly under-represented in the current literature, despite the high dance exposure associated with their roles.

**3.** There is a need for more high-quality prospective study designs to more appropriately determine injury risk in dance education settings.

## Introduction

Dance is a popular activity worldwide. In the United States, the prevalence of dance participation among adolescents was reported to be 21%[1] and is frequently reported to be in the top five most popular activities for adolescent girls across the globe[2-4]. Dancers typically begin participating recreationally or competitively at a young age and are taught by a dance instructor in private studio settings[5,6]. With increasing age and proficiency, some students choose to pursue pre-professional training (i.e., elite level training often focused on technical and artistic skill acquisition, with increased volume and higher intensities of training) en route to a professional career, while others continue training in private studio classes and/or post-secondary dance education[6]. This means that a large proportion of the Western concert dance community (e.g., ballet, modern, contemporary) is actively engaged in dance classes either as students or instructors, on a regular basis.

Dance participation carries an inherent risk of injury. For example, the annual prevalence of dance-related injury has been estimated at 43% among young female recreational dancers[7]. At the pre-professional level, annual prevalence of injury among ballet and modern dancers was estimated to be as high as 86%[8]. Injury incidence rates has been estimated to be between 1.09 - 4.7 injuries 1000 hours of exposure in pre-professional ballet and modern dancers[8-11]. In professional populations, these estimates are similar ranging from 0.29 - 4.1inj/1000hrs[12-14]. Of these injuries,

most result from repetitive stress and involve the lower extremity including the foot, ankle, shin, knee, hip, and low back[11,15-17]. A consistently identified risk factor for these injuries is dance exposure, with increasing hours of dance participation being associated with an increase in injury incidence[8,18-20].

While a considerable body of evidence that is focused on injury risk in pre-professional and professional dance populations is emerging[12,18,21], research focusing solely on the most common dance setting – the private dance studio – has been limited. Epidemiological studies examining pre-professional dancers in their training often include rehearsal and performance in exposure estimates, as these dancers are preparing for professional performance careers[17,21,22]. Considering that dancers across all levels take part in formal classes, that recreational and competitive student dancers spend most of their time in studio-related activities[23], and that not all dancers pursue performance careers, a gap in our current understanding of dance injury risk that is specific to the education setting, where the focus is on acquiring technical and artistic skill, exists. Moreover, instructors and educators, who often have long hours of daily and weekly dance exposure, are under-represented in the literature resulting in limited understanding of their injury risk when compared to dance student populations[24,25]. Greater clarity on the extent of injury in the dance studio environment would benefit an underserved majority of dancers and may lead to the development, implementation, and evaluation of effective injury prevention strategies[26].

Despite clear recommendations from the 2012 IADMS Standard Measures Consensus Initiative to improve dance injury epidemiology research, the use of different definitions for dance-related injury and different strategies to capture both injury and exposure data remain[22,27]. The use of valid

and reliable methodological approaches is important for improved understanding of dance-related injury risk. Further clarity is needed on the protocols and procedures commonly used in the literature to inform recommendations for injury surveillance studies that are of a high level and quality of evidence.

Therefore, the primary objective of this systematic review is to describe injury rates and characteristics associated with participation in organized dance education settings. Secondary objectives are to determine potential differences in injury rates/characteristics among dance teachers and their students and to identify common methodological approaches being utilized to capture injury outcomes in dance education settings.

## Methods

*Search Strategy*

Registration of this systematic review was made with PROSPERO (trial registration number: CRD42019142780) and conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines[28]. In consultation with a subject librarian, six electronic databases (Medline, EMBASE, SportDiscus, CINAHL, SCOPUS, Cochrane) were searched from inception to April 2021. Additional references were sought through journal searches and reference lists of included studies. Six key search themes were identified along with specific MeSH terms (i.e., dancing, teaching, students, wounds and injuries, athletic injuries, and pain) to maximize the number of relevant and retrievable articles (Table 1).

Upon completion of each database search, duplicates were removed, and titles and abstracts of the remaining articles were screened by pairs of reviewers, each of which included the senior author to ensure consistency (pair 1 = MC and CM; pair 2 = SK and CM; pair 3 = AR and CM; pair 4 = KC and CM). Two stages of screening occurred. First, reviewers screened the articles independently before reaching agreement within their pair. All disagreements were resolved through discussion. The same screening protocol was followed at the second stage to determine final article inclusion for abstracts progressing to full text review. Inter-rater reliability within reviewing pairs was assessed using Cohen's kappa coefficient at each stage.

*Eligibility Criteria*

Selected studies met *a priori* inclusion criteria that required original data from dance teacher and/or dance student samples within formal dance education settings (e.g., community-based classes, secondary school or university dance programs, designated classes undertaken during pre-professional/elite level training). All genres of dance were eligible. For the purpose of this review, all injury definitions were acceptable. Illnesses, mental health concerns, and physiological problems (e.g., relative energy deficiency/RED-S symptoms) were not included. Studies were also excluded if no injury outcomes or estimate of exposure were reported, if injuries occurred during rehearsal or performance, or if dance was used as a therapeutic intervention or for exercise. Case studies and case series were ineligible. Only English-language studies were retained for review.

*Study Design and Quality Appraisal*

Studies were classified by their overall design according to the guidelines of the Oxford Centre of Evidence Based Medicine (OCEBM), which ranks studies using a hierarchy of evidence ranging

from case reports (lowest) to randomised controlled trails (highest)[29]. The quality of evidence was evaluated based on criteria for internal validity (i.e., study design, reporting, presence of selection and misclassification bias, potential confounding) and external validity (i.e., generalisability) using the Joanna Briggs Institute (JBI) Level of Evidence checklists. The JBI checklists were chosen because they are specific to the identified study design (e.g., there are JBI checklist for quasi-experimental studies, cohort studies, analytical cross-sectional studies) (see Supplementary File 2)[30]. Checklists are also designed to be presented in their entirety to enable transparent assessment of study quality and discussion of methodological limitations when synthesizing evidence and forming conclusions, rather than produce a potentially biased numeric score representing a study's overall quality of evidence[16,31]. Two authors (MC and CM) independently conducted and subsequently discussed and agreed upon all study design categorizations and quality appraisals. Inter-rater reliability was calculated using Cohen's kappa coefficient. Scores were categorized as 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement[32].

*Data Extraction*

On completion of full text screening, two authors (MC and CM) extracted the following data from each study: year of publication, country of origin, participant characteristics, injury definition, outcomes, exposure, and details of the assessment tools used in the study. For studies that did not provide injury rates, estimates were made based on the reported injury and exposure values. For studies that did not include sufficient data for a rate calculation, injury point prevalence was estimated.

## Results

The initial database search identified 1,424 potentially relevant records, of which 26 were retained for review (Figure 1) [7,9,19,20,33-54]. The most common reasons for excluding studies at the full text review stage were that they did not include an estimate of dance exposure (n=27), the sample was not drawn from a dance education setting (n=13), or data was pooled from dance classes, rehearsals and performances in such a way that dance class-specific data could not be extracted (n=18). Together, these reasons accounted for 51% of exclusions. Inter-rater reliability among the pairs of reviewers across all stages of screening ranged from $\kappa$=0.43-0.71, indicating moderate to substantial agreement[55].

### *Study characteristics*

The included studies were published between 1995 and 2021, though the majority (n=21) were published after 2010 (Table 1). Eight were conducted in the United States[9,34-36,39,41,42,46], four in Israel[7,38,48,49], three in Germany[44,45,53], two in the United Kingdom[20,33], and nine other countries were represented by single studies[19,37,40,43,47,50,52,54]. One study utilized an online survey, but it is unclear whether this was global or restricted to a particular geographic area[51].

Most studies (n=23) focused on dance students only[7,9,19,20,33-43,45,46,48-50,52,54], three included only dance teachers[47,51,53] and one study included both[44]. Altogether, the study samples included 4,632 dance students (3,902 female, 730 male) and 430 dance teachers (281 female, 49 male). Individual study sample sizes ranged from 17 to 1,336 students and 32 to 151 teachers. Dance students were, on average, 18.8 years old whereas dance teachers had a mean age of 39.4 years. The most common research settings were either dance schools/academies (n=12)[9,19,20,37,38,40,43,45,47-49,54] or university

192 dance programs (n=8)[33-36,39,42,50], but studies also took place in community-based samples (n=2)[7,46]
193 and arts schools (n=2)[9,41]. In two cases, the setting was not described[44,51]. Most studies included
194 samples from multiple dance genres (n=14; most commonly a combination of ballet and
195 modern)[7,9,19,20,33-35,37,41,42,45,48-50]. Single-genre studies were conducted in ballet (n=3)[40,43,54],
196 modern (n=1)[39], contemporary (n=1), tap (n=1)[46] and highland dance (n=1)[52]. Genre was not
197 specified in five studies[36,38,44,47,51,53].
198
199 *Level of evidence and quality assessment*
200 Thirteen studies were cross-sectional (six descriptive, seven analytical)[20,43-54], 12 used a cohort
201 design (eight prospective, four historical)[7,9,19,33-41], and one used a quasi-experimental design[42].
202 The length of the cohort studies ranged from 14 weeks to 15 years. Overall, there were 13 Level
203 2b studies and 13 Level 4, according to the OCBEM criteria (Table 2 & 3). The quality of the
204 Level 2b studies was moderate (Table 4). This means that all of these studies reported enough
205 information about their samples and target populations such that the risk of selection bias was low.
206 Data was collected over a defined time period using broadly appropriate measurement strategies
207 to enable injury estimates to be calculated. However, exposure measurements were not thoroughly
208 reported, and analyses did not account for potential confounding by relevant variables such as age
209 or dance genre. Thus, there is a reasonable likelihood of error in the reported injury
210 incidence/prevalence estimates, although the direction and magnitude of the potential bias cannot
211 be determined from the available data.
212
213 The quality of the Level 4 studies was generally poor (Table 4). Amongst the prevalence studies,
214 no single paper achieved a "yes" rating in more than two quality assessment categories. All five

studies had a significant risk of selection bias, with insufficient sample sizes and low or unreported response rates. The cross-sectional studies were of similarly low quality, with the exception of the good-quality study conducted by Siev-Ner and colleagues[48]. Most authors reported how injuries were operationalized and how their data collection instruments captured potential confounding factors, but statistical analyses did not account for these potential confounders. There was also a significant risk of selection bias in six of the seven analytical cross-sectional studies. Altogether, the Level 4 studies yielded a high likelihood of error, which means that robust conclusions cannot be drawn from their results.

*Injury outcomes*

Injury definitions were explicitly stated in 23/26 studies, though definitions varied across the literature[7,9,19,33-35,37-50]. Injuries were captured if they were diagnosed by a medical professional (n=12),[7,19,33,37-42,47-49] or if participants self-reported pain/injury (n=15)[9,20,34-36,43-46,50-54]. Exposure was most often reported in units of hours/week (n=17)[7,19,35,38-40,42-46,48-54]. Exposure was also collected in hours/day (n=3)[9,47,51], hours/year (n=4)[20,33,37], dancing days/month (n=1)[34], and total person-days at risk (n=1)[41]. The single abstract included in this review did not specify how exposure was captured but provided an incidence rate estimate per hour of dance exposure[36].

For studies that reported injury rates (n=12; 10 cohort studies, 2 cross-sectional; all dance student samples)[9,19,20,33-37,40,41,46], seven used a standardized rate/1000hrs of dance exposure, whereas one reported rate/1000 dancer-days, one provided rate/1000 dance exposures and one reported a rate/hr. As reported in these studies, injury incidence was 0.8-4.7 injuries/1000hrs[9,19,20,33,37,40], 4.86/1000 dancer-days[41], 0.21-0.34/1000 dance exposures[46], and 0.47/hr[36], respectively. In the

238 study by Dipasquale, a figure depicting injury incidence/week[35] was included. In another study by
239 Dispasquale and colleagues, all dancing exposure (e.g., classroom and rehearsal time) was pooled
240 to report an incidence rate/day[34]. Based on calculations using data extracted from these studies,
241 the reported injury rates in dance class settings specifically were 7.9-8.3/1000 dancer-hrs and 0.39
242 injuries/day, respectively. Studies that used a medical assessment injury definition reported rates
243 from 0.8-4.7/1000hrs[7,19,33,37,40] or 4.9/1000 days[41]. The highest estimates came from studies that
244 defined injury as self-reported pain (0.39/day) or activity modification (7.9-8.3/1000 dancer-
245 hrs)[34,35]. However, based on the low to moderate quality of these studies, the reported and
246 calculated injury rate estimates could be under- or over-estimated.
247
248 Fourteen studies did not report an injury rate (3 cohort studies, 1 quasi-experimental, 12 cross-
249 sectional)[7,38,39,42-45,47-54] and data were extracted to calculate incidence rates/1000hrs of dance class
250 exposure (n=10) or point prevalence of injury (n=4). For dance students, estimates ranged from
251 2.6-33 injuries/1000 dancer-hrs, using a combination of self-reported and medical attention injury
252 definitions[35,39,43,50,52]. Studies that defined injury as self-reported pain yielded a rate of 12.6
253 injuries/1000 dancer-hrs[44] and point prevalence estimates ranging from 0.43-0.63
254 injuries/day[7,48,49]. For dance teachers, there was an estimated incidence rate of 4.8 injuries/1000
255 dancer-hrs based on a pain definition[44]. One study assessed dance teacher injuries using a
256 retrospective survey but did not indicate the time period over which exposure was captured,
257 resulting in a prevalence estimate of 0.86-1.25 injuries/dance teacher over an undefined period of
258 time[51]. A third study investigated dance teacher hearing loss and reported an incidence rate of
259 1.8/1000hrs[47]. Overall, the injury estimates based on data extracted from the poor-quality studies
260 not reporting specific injury incidence and prevalence need to be interpreted with caution.

For dance students, it was reported that 36.4-64.0% of injuries were new and 35.0-63.6% were recurrent or subsequent[9,19,34,35]. Studies indicated that 14.3-23.1% of injuries were acute[35,40] and 21.7-85.7% were overuse/chronic[9,33-35,37,40]. A high proportion (46.0-82.6%) of all reported injuries were to the lower limb[33-36,40,42]. Dance teacher injury types were only reported in one study, which found that 40.6% of injuries were acute, 59.4% were overuse/chronic, and 67.9% involved the lower limb[51]. Due to the heterogeneity in injury definitions and exposure measures across studies utilizing a prospective study design, it was not possible to assess the influence of specific risk factors (e.g., dance genre, education setting, gender, years of experience, etc.) on injury outcomes.

*Assessment tools*

Injuries were assessed through medical records or clinical examinations in thirteen studies[7,9,19,20,33,37-41,47-49]. Self-reported methods included bespoke questionnaires (n=8) and specific instruments (n=6) that included visual analogue scales[43,48,49], the Fit2Dance survey[56], a modified 'Dance Injury Survey'[46], an Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire modified for dance[57], and the Self-Estimated Functional Inability Because of Pain (SEFIP)[39,58]. Exposure was assessed in several different ways across the included studies. Attendance records/timetables were used as a gold standard in nine studies[19,33,35,37,40,41,46,50], but other approaches included bespoke questionnaires or recording forms (n=9), interviews (n=2), and the validated Fit2Dance survey[56] (n=1). Exposure capture tools were not described in five studies [36,38,42,43,49]. Psychometric properties were not reported for any self-reported instruments in any study.

## Discussion

The present systematic review aimed to describe injury rates and characteristics associated with participation in organized dance education settings. Secondary objectives were to determine whether dance teachers and their pupils differed in injury risk profiles and to identify what measurement tools have been used to capture injury outcomes in dance education settings.

### *Level of evidence and quality assessment*

The studies included in this review adopted observational designs that relied heavily on self-reported exposure and injury outcome information. These are hallmarks of injury surveillance in dance medicine[22,59], but more than half of the studies took a cross-sectional approach, which precludes the ability to make of causal inferences or appropriate injury risk estimation due to a lack of temporality in the study design[60]. With a lack of prospective studies to draw on, current understanding of injury risk in dance classes remains limited.

The overall quality of the studies in this review was rated as poor to moderate. Although the cohort studies fared somewhat better than the cross-sectional studies due to better reporting of sampling frames and participant characteristics, common risks of bias were present. Measurement error was of particular concern, as the validity and reliability of study measures were not reported in a single study. In general, statistical analyses were often conducted at the crude, or univariable level, and authors did not account for potential confounders. Together, these limitations highlight the potential for injury estimates to be under- or over-estimated, though the direction and magnitude of this bias likely varies between studies.

*Injury outcomes*

A wide range of definitions for dance injury and dance exposure were used across the literature. Dance injury epidemiology has traditionally been limited by the use of different definitions of dance-related injury[22]. Studies in this review adopted definitions ranging from "any physical complaint" to "time loss", and several included instances of pain and/or activity modification alongside self-reported or physician-diagnosed pathologies. This makes comparison between studies, or pooling injury data for more accurate injury estimates, difficult. Studies also lacked clear and consistent dance exposure measurement. This was typically operationalized by class schedules or captured using self-report methods, or in some cases not defined at all, resulting in a high risk of error. Self-report methods of injury are susceptible to social desirability and/or recall bias, which could lead to potential under-reporting[61], as does basing dance exposure on registered class time that does not account for absences. Conversely, dancers may under-report their overall exposure if they are asked only about their participation in a specific class, dance genre, or location. Injury rates, which require a measure of both exposure and outcome, may therefore be skewed, resulting in challenges when comparing or synthesizing data from different studies.

Recommended definitions of dance-related injury have been stated by the IADMS Standard Measures Consensus Initiative. Specifically, injuries are to encompass a diagnosis from a licensed healthcare professional and full time loss of activity for one or more days[27]. However, it has been shown that using a time loss or medical attention injury definition may lead to an underestimation of injury burden in dancing populations[22]. This may be related to the "fear and avoidance" culture often reported in dance, which may lead to under-reporting[62]. For example, it has been documented

that professional or pre-professional dancers who sustain an injury ignore pain or choose not to report their symptoms for fear of losing rehearsal time or jeopardizing their place in the company[63,64]. The extent to which this occurs amongst dance students or teachers is unknown, but it is possible that the same culture may be exist in the dance education environment as well [65,66].

The discrepancy in injury rates between included studies of this systematic review illustrates the necessity to advocate for standardized, inclusive operational definitions and reporting methods that will enable rigorous comparison and synthesis. For example, studies that used time loss or medical attention definitions found injury rates ranging from 0.8 injuries/1000hrs to 33 injuries/1000 dancer-hours, whereas those using self-reported pain or activity modification recorded rates of 12.6 -17.8 pain reports/1000 dancer-hours. Rates and proportions also used different units of exposure (e.g., /1000hrs, /day, /1000 days). It is therefore possible that studies using time loss or medical attention definitions underestimated the true burden of injury in dance education, but with small samples, wide confidence intervals, and relatively few studies using comparable means of reporting, the reason for such discrepant values is difficult to determine.

Additionally, there were seven distinct methods of capturing injury outcomes and four different approaches taken to assessing dance exposure within the reviewed studies. This large variety of assessment tools was used to capture both injury outcomes as well as exposure, and validity and reliability data for these tools was often unreported. Along with a definition for dance-related injury, the 2012 IADMS consensus recommended a definition of an exposure as "any participation in class, rehearsal, or performance in which the dancer was exposed to the possibility of injury."[52] This definition was under-utilized across this body of literature, resulting in complications

surrounding a definitive statement about the risk and incidence of injury in the dance education setting.

Despite these issues, the injury estimates reported for dance education settings are not entirely dissimilar to values reported for other dancing populations. In pre-professional ballet and modern dancers, the injury incidence rate has been estimated to be between 1.09 – 4.7 injuries/1000hrs of exposure[8-11]. Indeed, the injury prevalence in pre-professional ballet and modern dancers over the course of a year has been estimated to be as high as 86%[8]. These are broadly in line with the rates reported by studies in this review, although with their acknowledged limitations, such comparisons should be made with a high degree of caution. The injury rates reported for dance teachers are well outside of the rates reported for dancers in the extant literature but given the paucity of research in the dance teacher population, it would not be appropriate to speculate how injury risk might compare for this group.

Notably, most dance-related injuries in professional and pre-professional populations have been shown to result from repetitive stress and involve the lower extremity[5,7,10,11]. This is consistent with the evidence that 22-86% of dance student injuries in this review were classified as overuse or chronic, and as many as 76% were reported to involve the lower limb. Though injury types for dance teachers were only considered in one study, the similar findings that 59% were overuse or chronic and 68% occurred in the lower limb suggests that the lower extremity injuries resulting from gradual onset may be a consistent injury profile that is closely associated with dance as an activity rather than the genre, level, or setting of participation.

Because so few studies have specifically examined injury amongst dance teachers, it is unclear whether they have the same risk profile. Yet, a consistently identified risk factor for injury is dance exposure, with increasing hours of dance participation associated with an increase in injury incidence in pre-professional and professional companies[12,17,19]. As dance teachers reported spending up to 14.8 hours per day in the studio[44], it is reasonable to suggest that exposure along with previously identified risk factors from other dance settings likely play a role. Future research is warranted to determine the most salient risk factors for both students and teachers in order to identify potential risk mitigation strategies.

*Limitations*

Some important limitations of this systematic review need to be acknowledged. Six potentially relevant publications could not be retrieved, and one non-English language paper was excluded. It is unlikely that these would have significantly impacted the conclusions drawn, but it is noteworthy that there may be some relevant data that are not presently included. Similarly, 18 studies were excluded due to pooling of exposure data from dance classes with rehearsals and performances and as such, injury data specific to dance classes could not be subdivided or extracted.

The samples of the included studies were drawn from a variety of populations, with widely varied participant characteristics and dance genres, meaning that the findings are unlikely to be representative across dance education settings, participant groups, or geographic areas. Injury prevalence and incidence estimates were estimated based on information presented by the authors for 15/26 studies. Some of these calculated estimates were significantly higher than what is reported in previous literature due to the calculation of a temporal incidence rate from cross-

sectional data collected at one time point. Exposure may have been overestimated in calculations due to the inability to account for attendance of each participant at each dance session and all participants were assumed to have participated the same amount. This introduces a likelihood of error, particularly for those values derived from figures rather than raw data, though the overall influence of these estimates on the conclusions drawn from the systematic review is unlikely to be significant. Additionally, the quality of the included studies was generally low, meaning that injury estimates may be imprecise and should be interpreted with caution.

These limitations are counterbalanced by the strengths of the review's methodology. A transparent and robust approach was used during the literature searching and screening process, and well-established quality assessment tools were used to evaluate the retained publications. Data extraction was duplicated and verified, providing reassurance that the conclusions are based on a rigorous and replicable protocol.

*Implications*

The findings of this review highlight that what is known about injury risk in the dance education environment remains unclear. However, there is evidence that a meaningful number of dancers report pain, modified participation, and time loss associated with dance classes. By first acknowledging and raising awareness of this problem, practical steps can be taken to reduce the impact of these injuries on dancer and dance teacher health. Injury recognition may lead to improved medical management alongside activity modification to minimize burden within the classroom. Future research should focus on utilizing standardized inclusive injury definitions,

valid and reliable measurement tools, and reporting conventions that will enable more robust estimates of specific injury types. Identifying risk factors for injury should also be a priority in order to drive effective dance injury prevention efforts forward.

## Conclusion

A small body of literature exists from which to draw evidence regarding injury risk in dance education settings. It appears that injuries are predominantly overuse or chronic and occur mostly in the lower extremity, and these characteristics hold for both students and teachers. However, based on the low quality and level of evidence demonstrated by these studies, injury rates cannot be confidently synthesized, and the true burden of dance injury specific to the dance education environment cannot be quantified. Furthermore, dance teachers are greatly under-represented in the current literature, despite the high dance exposure associated with their roles. In order to appropriately protect the health and wellbeing of dance students and teachers, there is a pressing need to address these shortcomings and to prioritize these populations in future high-quality dance injury epidemiology research.

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Table 1. Medical Subject Headings (MeSH) and text words (tw) utilized for online systematic search strategy.

| **Concept A (Population)** | **Concept B (Activity)** | **Concept C (Setting)** | **Concept D (Injury)** |
|---|---|---|---|
| Dancing (MeSH)<br>Teaching (MeSH)<br>Students (MeSH) | Danc* (tw)<br>Ballet (tw)<br>Hip-hop (tw) | Lesson* (tw)<br>Program* (tw)<br>Class *(tw)<br>Instruct* (tw)<br>Teach* (tw)<br>Syllab* (tw)<br>School* (tw)<br>Studio* (tw)<br>Train* (tw)<br>Vocation* (tw) | Wounds and Injuries (MeSH)<br>Athletic Injuries (MeSH)<br>Pain (MeSH) |

MeSH, Medical Subject Heading; tw, text word.

Table 2. Study characteristics and reported injury data of included Level 2b studies (n=13).

| Author, year, country | Study design | Dance setting and genre | Sample | Outcome definition and assessment | Exposure assessment | Injury estimate | Reported injury rates | Calculated estimates[#] | Injury and exposure assessment tools |
|---|---|---|---|---|---|---|---|---|---|
| **Oxford Level of Evidence 2b (Prospective)** | | | | | | | | | |
| Armstrong et al.[33]<br><br>2020<br><br>UK | Prospective cohort | University dance program (included ballet, contemporary, and jazz) | n=82 dance students<br><br>62 female<br>20 male<br><br>20.33 ± 0.68 | Time loss: involved an absence from dancing for 1 or more days<br><br>Medical attention: involved an injury that required the attention of the researcher but did not result in time loss | Recorded from weekly attendance register<br><br>39,692 hours<br><br>Female: 29,717 hours<br><br>Male: 9975 hours | 47 injuries occurred in 34 dancers<br><br>Time loss: 41 (87.2%)<br><br>Medical attention: 6 (12.7%)<br><br>Traumatic: 25 (53.2%)<br>Overuse: 22 (46.8%)<br><br>33/47 (70.2%) occurred in the lower limb | Time loss:<br><br>Pooled 1.03 inj/1000h<br><br>Female 1.04 inj/1000h<br><br>Male 1.00 inj/1000h<br>Medical attention:<br><br>Pooled 1.18inj /1000h<br><br>Female 1.25inj /1000h<br><br>Male 1.00inj /1000h | - | Clinical examination<br><br>Attendance register |
| DiPasquale et al.[34]<br><br>2015 | Prospective cohort<br><br>4 months | University dance department (included ballet, tap, | n = 46 dance students<br><br>41 female<br>5 male | Self-reported pain preventing full participation | Dancing days per month based on academic calendar | 46/168 students reported an injury<br><br>Injuries by month: | 56.5% of injuries occurred in class | Overall class-only rate: 0.39 inj/day (95% | Bespoke online or paper-based questionnaire |

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| USA | | modern, improvisation, jazz) | 19.61 ± 1.31 yrs | in dance classes | September – 20<br>October – 22<br>November – 17<br>December – 8 | September – 19<br>October – 12<br>November – 10<br>December – 5<br><br>63% new injuries<br>37% recurrent<br><br>21.7% overuse injuries<br><br>Most injuries to ankle, foot and knee (15.2% each) | September * - 0.95 inj/day<br><br>October* – 0.55 inj/day<br><br>November * – 0.59 inj/day<br><br>December * – 0.59 inj/day | CI: 0.27 – 0.52) | |
| DiPasquale[35]<br><br>2018<br><br>USA | Prospective cohort<br><br>14 weeks | University dance department (included ballet and modern) | n = 22 dance students (11 dance majors, 11 minors)<br><br>20 female<br>2 male<br><br>Majors: 20.18 ± 1.25 yrs<br><br>Minors: 20.36 ± 1.29 yrs | Self-reported impairment resulting in full time loss or dance modification for one or more days beyond the day of onset | Class timetable<br><br>Majors: 11.38 ± 2.47 hrs/wk<br><br>Minors: 8.56 ± 4.14 hrs/wk | Majors: 14 injuries / 7 dancers (9 new, 5 reinjuries); 12 overuse, 2 traumatic<br><br>Minors: 11 injuries / 5 dancers (4 new, 7 reinjuries); 9 overuse, 2 traumatic<br><br>Most injuries to knee (n=5), lower leg (5), foot (4), ankle (3) | Weekly incidence rate displayed in figure | Majors: 7.9 inj/1000 dancer-hrs (95% CI: 3.8-12.2)<br><br>Minors: 8.3 inj/1000 dancer-hrs (95% CI: 3.4-13.3) | Bespoke exposure spreadsheet<br><br>Injury questionnaire (no details provided) |

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| Grierson, et al.[36]<br><br>2013<br><br>USA<br><br>Abstract only | Prospective cohort<br><br>4 months | 2 collegiate dance programs (genre not reported) | n = 36 dance students<br><br>34 female<br>2 male<br><br>20.8 ± 1.8 yrs | Self-reported dance-related injury<br><br>No injury definition provided | Unreported assessment method | 69.4% of dancers reported an injury<br><br>1.5 ± 1.6 injuries/injured dancer<br><br>60% lower limb injuries | 0.47 ± 0.6 injuries/hr | - | Online survey every two weeks (no details provided) |
| Luke et al.[9]<br><br>2002<br><br>USA | Prospective cohort<br><br>9 months | Liberal arts high school (ballet and modern) | n = 39 dance students<br><br>34 female<br>5 male<br><br>14-18 yrs (x=15.8 ± 1.0) | Self-reported and Physical Therapist report | Self-reported hours per day during a 2 wk teaching block<br><br>3.2 hrs/day | 112 injuries reported by 35 students<br><br>56.3% new injuries<br>43.7% recurrent<br><br>54% overuse injuries | 4.7 inj/ 1000 h (95% CI: 3.8-4.6) [note: upper limit is as reported by authors] | - | Survey (no detail provided)<br><br>Medical records |
| Moita et al.[37]<br><br>2019<br><br>Portugal | Prospective cohort<br><br>3 years | Dance school (included ballet and contemporary) | n=209 dance students<br><br>141 female<br>68 male | Any physical complaint sustained by a dancer resulting from dance practice, diagnosed by a licensed health care practitioner and which irrespective of the need for medical attention, | Recorded from weekly timetables<br><br>Median exposure: 400.6 hours per year | Year 1: 213 injuries<br><br>Year 2: 209 injuries<br><br>Year 3: 203 injuries<br><br>Acute: 32.5%<br>Overuse: 67.5% | 0.08-2.19/1000 hrs for females<br><br>0.8 - 2.8/1000 hrs for males | - | Clinic visits<br><br>Weekly timetables |

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| | | | | implies full or partial dance activity impairment for one or more days beyond onset | | | | | |
| Steinberg et al.[38]<br><br>2020<br><br>Israel | Prospective cohort<br><br>2 years | Vocational dance programme (genre not reported) | n=67 dance students<br><br>All female<br><br>12.8 ± 0.5 | Diagnosis of patellofemoral pain (PFP) | Assessment method unspecified<br><br>Baseline: 12.0 ± 3.2 hrs/week<br><br>1st follow up: 13.4 ± 3.8 hrs/week<br><br>2nd follow up: 14.8 ± 4.6 hrs/week | Baseline: 16.4% unilateral PFP 46.3% bilateral PFP<br><br>1st follow up: 20% unilateral PFP 64.6% bilateral PFP<br><br>2nd follow up: 33.3% unilateral PFP 31.4% bilateral PFP | None | Baseline: 1.0 PFP/1000 dancer-hrs (95% CI: 0.67-1.24)<br><br>1st Follow-up: 1.2 PFP/1000 dancer-hrs (95% CI: 1.5-8.9)<br><br>2nd Follow-up: 0.8 PFP/1000 dancer-hrs (95% CI: 0.6-1.1)** | Clinical examination |
| Weigert & Erickson[39]<br><br>2007<br><br>USA | Prospective cohort<br><br>2 academic semesters^ | University dance program (modern) | n = 30 modern dance majors (students)<br><br>All female | Medical attention and self-reported injury | Self-reported<br><br>13.24 ± 5.70 hrs/wk | 62% reported injury in previous year<br><br>30% had medical attention injuries in first semester; | None | Semester 1: 3.1 inj/1000 dancer-hrs (95% CI: 1.6-4.5)<br><br>Semester 2: | Bespoke injury questionnaire<br><br>SEFIP questionnaire |

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| | | | 18-26 yrs (x=20.4 ± 1.8) | | | 4 traumatic & 5 overuse (67% self-reported inj)<br><br>36.4% had medical attention injuries in second semester; 1 traumatic & 7 overuse (77% self-reported inj) | | 3.6 inj/1000 dancer-hrs (95% CI: 2.1-5.1) | Clinic records |
| **Oxford Level of Evidence 2b (Retrospective)** | | | | | | | | | |
| Fuller et al.[19]<br><br>2020<br><br>Australia | Retrospective cohort<br><br>3 years | Tertiary training program (included ballet and contemporary) | n = 17 dance students<br><br>16 female<br>1 male<br><br>20.7 ± 1.32 | Required medical attention | Dance hours each week from timetables.<br><br>Semester 1: 5933.75<br>Semester 2: 8096.25<br>Semester 3: 6970.00<br>Semester 4: 7522.50<br>Semester 5: 7269.00<br>Semester 6: 8111.50 | 119 injuries recorded<br><br>Ankle: 17.65%<br>Knee: 16.81%<br>Hip: 13.45% | Medical attention: 2.71/1000h (95% CI: 2.22, 3.20)<br><br>Time loss: 0.07/1000h (95% CI: -0.01, 0.15) | - | Clinical examination<br><br>Clinic charts<br><br>Enrolment and timetables |
| Leanderson et al.[40]<br><br>2011<br><br>Sweden | Retrospective cohort<br><br>7 years | Public ballet school | n = 476 dance students<br><br>297 female<br>179 male<br><br>10-21 years old | Medically assessed injuries | Attendance records<br><br>6-15 hrs/wk | 210 (44%) dancers reported injuries<br><br>101 traumatic<br>337 overuse | 0.8 inj/1000h overall<br><br>≤ 10 yrs old: f = | - | Clinical records<br><br>School attendance records |

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| | | | | | | 76% of injuries to lower extremity | 0.3; m = 0.5/1000h<br><br>11-14 yrs old: f = 0.7; m = 0.6/1000h<br><br>15-21 yrs old: f = 0.9; m = 1.1/1000h | | |
| Steinberg et al.[7]<br><br>2012<br><br>Israel | Retrospective cohort<br><br>15 years | Recreational dancers (including ballet, modern, jazz) | n = 1336 dance students<br><br>All female<br><br>8-16 yrs (x=13.3) | Medically assessed injuries | Interview<br><br>Mean 3 (SD 2) to 11 (SD 4) hrs/wk | 569 dancers were injured on day of assessment | None | Point prevalence: 0.43 injured dancers/ day (95% CI: 0.40-0.45) | Clinical interview<br><br>Clinical examination |
| Yau et al.[41]<br><br>2017<br><br>USA | Retrospective cohort<br><br>6 years | Arts school (ballet & modern) | n = 480 dance students<br><br>371 female<br><br>109 male | Medical attention injury with time loss or activity modification for at least 1 day | Enrollment dates at the school<br><br>Total 208,714 person-days at-risk | 480 dancers reported 1014 injuries | 4.86 inj/1000 dancer-days | - | Medical records |
| **Oxford Level of Evidence 2b (Quasi-experimental)** | | | | | | | | | |
| Skvarla et al.[42]<br><br>2019<br><br>USA | Quasi-experimental<br><br>6 weeks | University dance program (included modern and ballet) | n=30 dance students<br><br>26 female<br>4 male<br><br>19.77 yrs ± 1.45 | Diagnosed by athletic trainer or physician irrespective of time loss | Assessment method not specified<br>Controls: 18.33 ± 3.58 hrs/week<br><br>Treatment: 17.71 ± 4.69 hrs/week | 109 injuries reported<br><br>82.6% involved lower extremity | None | 33 inj/1000 dancer-hrs (95% CI: 26.8-39.2)* | Injury tracking survey (not validated) |

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[#] Estimated based on injury and exposure / denominator data available within the publication
* Reported rate pools dance class and rehearsal/performance data; calculated rate includes dance class data only
^ Calculated rates assume 12 teaching weeks per semester
** Follow-up cases were not specified if new or recurrent

Table 3. Study characteristics and reported injury data of included Level 4 studies (n=13).

| **Oxford Level of Evidence 4** | | | | | | | | | |
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| Drezewska & Sliwinski[43]<br><br>2013<br><br>Poland | Cross-sectional (prevalence) | Ballet school | n = 71 ballet students<br><br>45 female<br>26 male<br><br>15-18 yrs (x=16.5) | Self-reported lumbosacral pain | Unreported assessment method<br><br>10-30 hrs/wk (x=19.7 hrs) | 44 (28 girls, 16 boys) had lumbosacral pain for at least 3 months | None | 2.6 inj/1000 dancer-hrs (95% CI: 1.8 -3.4) | Questionnaire (no details provided)<br><br>0-100 pain visual analogue scale<br><br>Medical records |
| Lampe et al.[44]<br><br>2019<br><br>Germany | Cross-sectional (analytical) | No details provided | n = 205 amateur dance students<br><br>All female<br><br>24.0 ± 13.0 yrs<br><br>N = 151 dance teachers<br><br>All female<br><br>46.0 ± 18.0 yrs | Self-reported pain in previous 3 months | Self-reported<br><br>Dancers: 5.5 ± 4.9 hrs/wk<br><br>Teachers: 14.8 ± 9.2 hrs/wk | 171 dancers and 130 dance teachers reported pain | None | Dancers: 12.6 pain reports/ 1000 dancer-hrs (95% CI: 10.6-14.5)<br><br>Teachers: 4.8 pain reports/ 1000 dancer-hrs (95% CI: 3.9-5.7) | Online questionnaire |

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| Lampe et al.[45]<br><br>2019<br><br>Germany | Cross-sectional (prevalence) | Recreational studios (included ballet, contemporary, modern, and jazz) | n= 145 non-professional dance students<br><br>All female<br><br>64 ballet<br>29.5 ± 18.3<br><br>81 jazz/modern/contemporary (JMC)<br>25.0 ± 14.0 | Self-reported dance-related pain within previous 3 and 12 months | Self-reported<br><br>Ballet:<br>4.0 ± 3.5 hrs/week<br><br>JMC:<br>4.5 ± 3.9 hrs/week | 124 dancers reported pain during class<br><br>Most common painful body regions presented in Table 4 | None | 17.8 pain reports/1000 dancer-hrs (95%CI: 14.3-20.9)* | Online questionnaire |
| Mayers et al.[46]<br><br>2003<br><br>USA | Cross-sectional (prevalence) | Classes at a tap dance festival (dancers and dance teachers taking classes) | n = 104 dance students<br><br>90 female<br>14 male<br><br>15-75 yrs (x= 34 ± 14) | Self-reported MSK episodes resulting in missed dance time | Estimated based on years of experience and average class frequency per week<br><br>Average 21 years experience (range 1-60)<br><br>Self-reported average 5hrs/wk spent in dance classes | 59% of dancers reported an injury<br><br>87 injuries reported by female dancers<br><br>9 injuries reported by male dancers | 0.34 inj/1000 dance exposures (female)<br><br>0.21 inj/1000 dance exposures (male) | - | Modified dance injury survey |
| McMahon et al. [54]<br><br>2021<br><br>Australia | Cross-sectional (analytical) | Elite ballet schools (ballet) | n= 32 dance students<br><br>All female<br><br>18.23 ± 1.72 | Self-reported injury, body site, side, and type in the last 12 months | Unreported assessment method<br><br>13.37 ± 7.06 hrs/week | 17/32 (53.1%) reported one lower extremity injury in the past 12 months | None | 0.76 inj/1000dancer-hrs (95% CI: 0.39-1.12) | Online questionnaire |

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| | | | | | 48.83 ± 30.4 hrs/month | | | | |
| Nehring et al.[47]<br><br>2015<br><br>Brazil | Cross-sectional (analytical) | Dance academies (dance genres not defined) | n = 32 dance teachers<br><br>22 female<br>10 male<br><br>32.03± 10.95 yrs | Objectively measured hearing loss | Self-reported<br><br>Mean 22.06 years of teaching<br><br>Range 1-10 hrs/day teaching (mean 4.52) | 4 teachers had hearing loss in right ear between 4-8kHz<br><br>5 had hearing loss in left ear between 4-8kHz | None | 1.8 reports of hearing loss / 1000hrs (95% 0.8-3.4) | Hearing evaluation using otoscope<br><br>Davis and Silvermann classification of hearing loss |
| Siev-Ner et al.[48]<br><br>2018<br><br>Israel | Cross-sectional (analytical) | 3 schools with dance programs (ballet and modern) | n = 67 dance students<br><br>All female<br><br>12.8±0.5 yrs | Patellofemoral pain assessed using 4th Patellofemoral Pain Consensus Statement criteria | Interview<br><br>12.0±3.2 hrs/wk in previous year | 11 dancers had unilateral pain on day of assessment<br><br>31 dancers had bilateral pain on day of assessment | None | Point prevalence: 0.63 injured dancers/ day (95% CI: 0.50-0.74) | Interviews<br><br>Clinical examination (Pain VAS scale) |
| Steinberg et al.[20]<br><br>2014<br><br>UK | Cross-sectional (prevalence) | 8 centres for advanced training in dance (modern, ballet, urban, creative dance) | n = 806 dance students<br><br>588 female<br>218 male<br><br>10-18 yrs (x=13.5±2.3) | Self-reported injury in the past 12 months<br><br>No injury definition provided | Self-reported<br><br>8-10 yr olds: 445.5 hrs/yr per dancer (SD 123.1)<br><br>11-12 yr olds: 464.1 hrs/yr per dancer (SD 145.8)<br><br>13-15 yr olds: 188.9 hrs/yr | 347 dancers reported 525 injuries | 8-10 year olds: 1.32 inj/1000h (95% CI: 0.98-1.77)<br><br>11-12: 1.55 inj/1000h (95% CI: 1.31-1.83)<br><br>13-15: .1.24 inj/1000h | - | Fit to Dance survey |

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| | | | | | per dancer (SD 183418.5)<br><br>16-18 yr olds: 266.8 hrs/yr per dancer (SD 97482.6) | | (95% CI: 1.09-1.41)<br><br>16-18: 1.17 inj/1000h (95% CI: 0.97-1.40) | | |
| Steinberg et al.[49]<br><br>2018<br><br>Israel | Cross-sectional (analytical) | 3 schools with dance programs (ballet and modern) | n = 36 pre-menarche dance students<br><br>n = 31 post-menarche dance students<br><br>All female<br><br>12.8 ± 0.5 yrs | Patellofemoral pain assessed using 4th Patellofemoral Pain Consensus Statement criteria | Unreported assessment method<br><br>12.0 ± 3.2 hrs/wk in classes | 52.2% of pre-menarche dancers reported PFPS<br><br>57.4% of post-menarche dancers reported PFPS | None | Point prevalence pre-menarche: 0.52 injured dancers/ day (95% CI: 0.33-0.67)<br><br>Point prevalence post-menarche: 0.57 injured dancers/ day (95% CI: 0.39 -0.75) | Interviews<br><br>Clinical examination (Pain VAS scale) |
| To et al.[50]<br><br>1995<br><br>Hong Kong | Cross-sectional (analytical) | Collegiate dance program (ballet and 'non-ballet') | n = 98 dance students<br><br>All female<br><br>17-33 yrs (mean = 21)<br><br>n = 70 eumenorrhoeic | Self-reported injury sustained during training that resulted in time taken off or that required medical consultation | School schedules and training diaries<br><br>Eumen. dancers: 26.64 ± 8.27 hrs/wk | Eumen. dancers: 5 – 5+ injuries 36 – chronic orthopedic problem<br><br>Oligomen. dancers: 5 – 5+ injuries | None | Eumen. 0.76 chronic inj/1000 dancer-hrs (95% CI: 0.49-0.95)<br><br>Oligomen. 0.98 chronic inj/1000 dancer-hrs | Questionnaire (no details provided) |

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| | | | n = 15 oligomenorrhoeic<br><br>n = 13 amenorrhoeic | in the past 6 months | Oligomen. dancers: 28.60 ± 7.36 hrs/wk<br><br>Amen. dancers: 30.54 ± SD 6.47 hrs/wk | 11 – chronic orthopedic problem<br><br>Amen. dancers: 5 – 5+ injuries<br>11 – chronic orthopedic problem | | (95% CI: 0.40-1.56)<br><br>Amen. 1.06 chronic inj/1000 dancer-hrs (95% CI: 0.43-1.69) | |
| Wanke et al.[51]<br><br>2014<br><br>Country not defined | Cross-sectional (prevalence) | Dance teacher associations and websites (genres not defined) | n = 104 dance teachers<br><br>78 female<br>26 male<br><br>21-66 yrs (x=40.3 ± 11.6) | Self-reported acute or chronic complaint<br><br>No injury definition provided | Self-reported<br><br>6±2.4 hrs/day<br><br>31±14.5 hrs/wk<br><br>Timeframe of study not reported | 89 acute work-related injuries<br><br>130 chronic work-related problems<br><br>Lower limb: 67.9% acute; chronic 60.8%<br><br>Spine: 21.8%<br><br>Upper limb: 10.3% | None | Acute: 0.86 inj/person (95% CI: 0.78 -0.91)<br><br>Chronic: 1.25 inj/person (95% CI: 1.04-1.5) | Questionnaire face validated by dance teachers and medical doctors |
| Wanke et al.[53]<br><br>2021<br><br>Germany | Cross-sectional (analytical) | Various dance associations and websites (genre not defined) | n = 143 dance teachers<br><br>130 female<br>13 male<br><br>Median = 45 years old | Self-reported pain during dancing or within 24 h thereafter taking into account the temporal occurrence of muscle ache | Self-reported class hours<br><br>Median = 15.0 hrs/wk | 143 dance teachers reported pain in a 3 month period | None | 5.5 inj/1000 dancer-hrs (95% CI: 4.5-6.4) | Questionnaire based on the Birbaumer and Schmidt model of pain perception and behaviour[67] |

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| Young & Paul[52]<br><br>2002<br><br>Scotland | Cross-sectional (prevalence) | 2 highland dance competitions | n = 33 dance students<br><br>Gender unreported<br><br>Age unreported | Self-reported injuries to Achilles tendon in the previous 12 months<br><br>No injury definition provided | Self-reported class hours<br><br>2.5-6.5 hrs/wk (extracted from figure) | 10 reported Achilles tendon injuries | None | Estimate range: 0.9 (95% CI: 0.3-1.4) to 2.3 (95% CI: 0.8-3.7) Achilles inj/1000 dancer-hrs | Bespoke questionnaire |

# Estimated based on injury and exposure / denominator data available within the publication
* Reported rate pools dance class and rehearsal/performance data; calculated rate includes dance class data only
^ Calculated rates assume 12 teaching weeks per semester
** Follow-up cases were not specified if new or recurrent

Table 4. Study quality appraisal of included studies as per Joanna Briggs Institute (JBI) Level of Evidence checklists.

| Study | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **JBI Critical Appraisal Checklist for Cohort Studies** | | | | | | | | | | | |
| Armstrong et al. 2020 | Y | Y | Y | N | N | Y | Y | Y | U | U | Y |
| Di Pasquale et al. 2015 | Y | Y | N | N | N | U | U | Y | U | U | N |
| Di Pasquale et al. 2018 | Y | Y | N | N | N | U | Y | Y | Y | Y | N |
| Fuller et al. 2020 | Y | Y | Y | N | N | U | Y | Y | Y | N/A | Y |
| Grierson et al. 2013 | Y | Y | U | U | U | Y | Y | Y | U | U | U |
| Luke et al. 2002 | Y | Y | U | Y | N | N | Y | Y | U | U | N |
| Weigert & Erickson 2007 | Y | Y | U | Y | Y | N | Y | Y | Y | U | N |
| Leanderson et al. 2011 | Y | Y | Y | Y | Y | U | Y | Y | Y | U | N |
| Moita et al. 2019 | Y | Y | Y | N | N | U | Y | Y | U | U | Y |
| Steinberg et al. 2012 | Y | Y | U | Y | Y | N | Y | U | U | U | Y |
| Steinberg et al. 2019 | Y | Y | U | N | N | N | Y | Y | Y | N/A | Y |
| Steinberg et al. 2020 | Y | Y | U | N | N | N | Y | Y | Y | N/A | Y |
| van Winden et al. 2019 | Y | Y | Y | N | N | U | Y | Y | Y | N/A | Y |
| Yau et al. 2017 | Y | Y | Y | Y | Y | U | Y | Y | U | U | Y |
| **JBI Critical Appraisal Checklist for Quasi-Experimental Studies** | | | | | | | | | | | |
| Skvarla et al. 2019 | Y | Y | Y | Y | Y | Y | Y | U | Y | | |
| **JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data** | | | | | | | | | | | |
| Drezewska & Sliwinski 2013 | U | U | N | N | Y | Y | U | N | U | | |
| Lampe et al. 2019 | Y | Y | N | Y | N | Y | Y | Y | U | | |
| Mayers et al. 2003 | U | N | N | Y | Y | N | N/A | N | N | | |
| Steinberg et al. 2014 | Y | U | Y | Y | U | U | U | N | U | | |
| Wanke et al. 2014 | U | N | N | N | U | N | N/A | N | N | | |
| Young & Paul 2002 | U | U | N | N | N | N | N/A | N | N | | |
| **JBI Critical Appraisal Checklist for Analytical Cross-sectional Studies** | | | | | | | | | | | |
| Lampe et al. 2019 | Y | N | N | Y | Y | N | U | N | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| McMahon et al. 2021 | Y | Y | U | Y | N | N | Y | Y | | | |
| Nehring et al. 2015 | Y | N | Y | Y | U | N | Y | Y | | | |
| Siev-Ner et al. 2018 | Y | Y | U | Y | Y | Y | Y | N | | | |
| Steinberg et al. 2018 | N | Y | U | Y | Y | N | Y | N | | | |
| To et al. 1995 | N | N | Y | U | Y | N | N | N | | | |
| Wanke el al. 2021 | Y | Y | U | Y | N | N | Y | Y | | | |

Note: Y = yes; N = no; U = unsure; N/A = not applicable; shaded squares indicate the question was not included on the study design specific checklist

**PRISMA Flow Diagram**

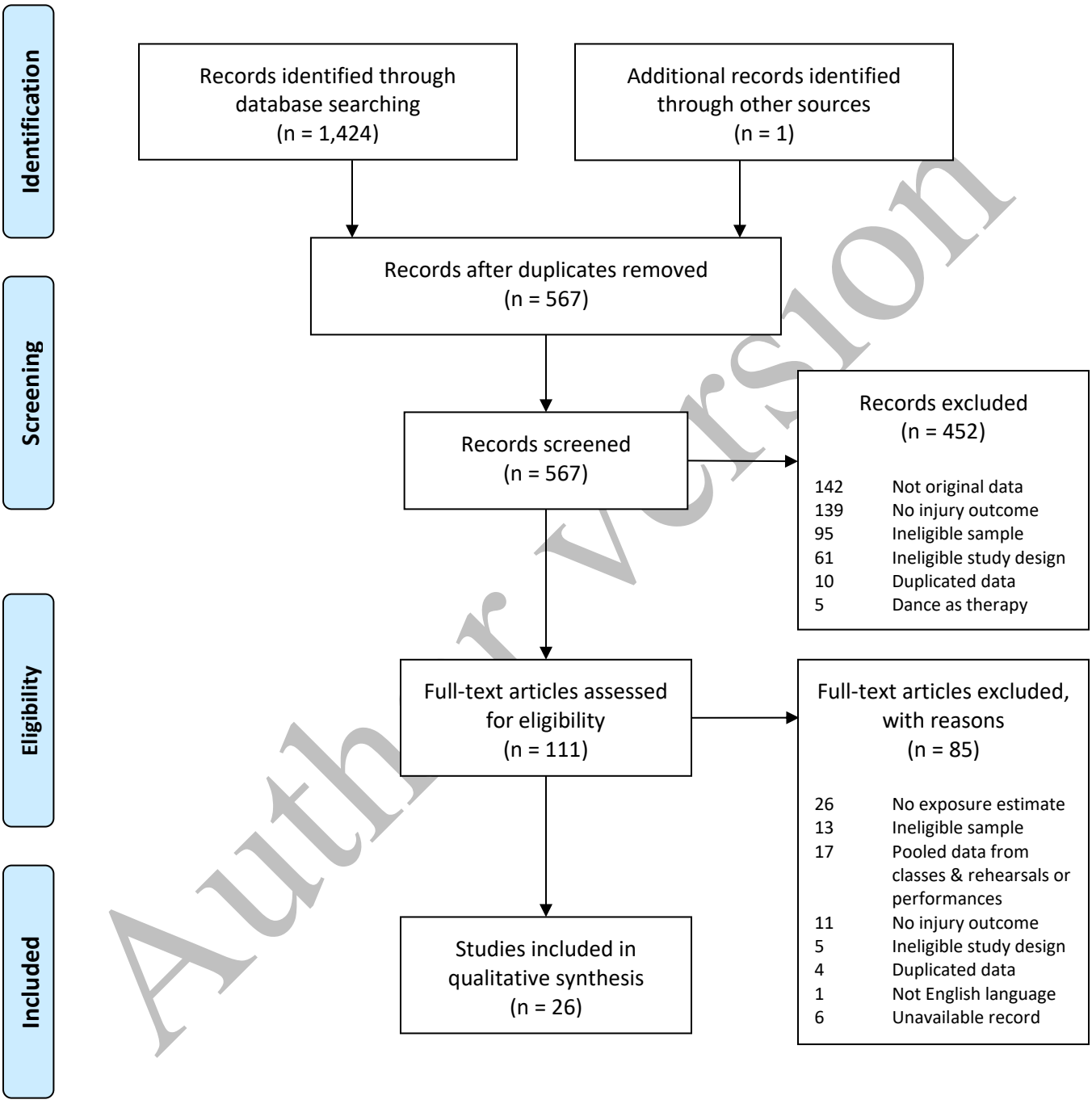




Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram for study selection.