Physical Therapy in Sport

Title Page

Extended Title: Prevalence and profile of musculoskeletal injuries in ballet dancers: A systematic review and meta-analysis

Short Title: Musculoskeletal injury in ballet

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Declarations

The manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Abstract

Aim: To determine the prevalence of musculoskeletal disorders and anatomical regions which are most frequently injured in ballet dancers.

Methods: Published (AMED, CiNAHL, EMBASE, SPORTDiscus, psycINFO, MEDLINE, the Cochrane Library) and grey literature databases (OpenGrey, the WHO International Clinical Trials Registry Platform, Current Controlled Trials and the UK National Research Register Archive) were searched from their inception to 25th May 2015 for papers presenting data on injury prevalence in ballet dancers. Two reviewers independently identified all eligible papers, data extracted and critically appraised studies. Study appraisal was conducted using the CASP appraisal tool. Pooled prevalence data with 95% confidence intervals were estimated to determine period prevalence of musculoskeletal disorders and anatomical regions affected.

Results: Nineteen studies were eligible, reporting 7332 injuries in 2617 ballet dancers. The evidence was moderate in quality. Period prevalence of musculoskeletal injury was 280% (95% CI: 217%-343%). The most prevalent musculoskeletal disorders included: hamstring strain (51%), ankle tendinopathy (19%) and generalized low back pain (14%). No papers explored musculoskeletal disorders in retired ballet dancers.

Conclusions: Whilst we have identified which regions and what musculoskeletal disorders are commonly seen ballet dancers. The long-term injury impact of musculoskeletal disorders in retired ballet dancers remains unknown.

Keywords: Ballet; dancing; musculoskeletal disorder; prevalence; risk factors

PROSPERO Registration: CRD42014013750

Introduction

Ballet dancers are athletes who, due to the activities and training they partake in at the extremes of joint capabilities, are at significant risk of musculoskeletal injury. These injuries are invariably overuse in nature (Ekegren, Quested, & Brodrick, 2014; American Academy of Pediatrics Committee of Sports Medicine and Fitness, 2000). Professional dancers frequently begin their specialist training from an early age, frequently becoming full-time dancers from the age of 15 years and over (Ekegren et al., 2014; American Academy of Pediatrics Committee of Sports Medicine and Fitness, 2000). Thus, when associated with adolescent growth spurts, and a developing musculoskeletal system, such dancers are at greater risk of growth-related overuse injuries which may become longer-term chronic musculoskeletal disordersinjuries (Ekegren et al., 2014; American Academy of Pediatrics Committee of Sports Medicine and Fitness, 2000).

Musculoskeletal pathologies, have been cited as a potential cause of long-term disability and a reduction in quality of life for physically active people (Kirkness & Ren, 2015). Previous studies have reported an association between engagement in physically-demanding activities such as football, netball and athletics and the development of long-term musculoskeletal pain and disability (Whittaker et al., 2015). There is limited understanding on whether such a similar association is evident in recreational, semi-professional and professional ballet dancers (Hincapie, Morton, & Cassidy, 2008). Hincapie et al (2008) previously systematically reviewed the literature on musculoskeletal injuries in dancers. This provided a valuable basis, but did not aim to explore musculoskeletal injuries in retired ballet dancers and their search was last updated in 2004.

The purpose of this review was to examine the current evidence-base on the prevalence and nature of musculoskeletal disorders in ballet dancers. We aimed to answer the following questions: (1) what is the prevalence of musculoskeletal injury in ballet dancers? (2) what are the most frequent types of musculoskeletal injuries experienced by ballet dancers? (3) which are the most frequent anatomical regions affected by musculoskeletal injuries in ballet dancers? and (4) what is the prevalence of chronic musculoskeletal disorders in ballet dancers once they retire from ballet?

Materials and Methods

Search Strategy

The primary search was of the electronic databases: AMED, CiNAHL, EMBASE, SPORTDiscus, psycINFO, MEDLINE and the Cochrane Library, which were searched from their inception to 25th May 2015.

The secondary search included the electronic databases of unpublished evidence: OpenGrey, the WHO International Clinical Trials Registry Platform, Current Controlled Trials and the UK National Research Register Archive were also reviewed from inception to 25th May 2015. The electronic search for the MEDLINE search is presented in **Supplementary Table 1**. This was amended for each individual database. The reference lists of each eligible paper were assessed for any additional papers. Finally, the corresponding authors from all included citations were emailed to identify any additional papers.

Eligibility Criteria

Participants: We included all studies of cohorts where 80% or over of the cohort were described as being 'ballet dancers' or where the data for ballet dancers were presented separately to other forms of dance. We included recreational, semi-professional and professional dancers.

Outcomes: We included all papers which presented data on the musculoskeletal profiles of ballet dancers. Data were sought on the incidence (assessing 'new' injury occurrence prospectively for a specific period of time) or prevalence (assessing injury presence in a cross-sectional 'snap-shot' (point prevalence) or at some time over a given period (period prevalence)) of chronic musculoskeletal disorders in ballet dancers. Musculoskeletal pain, injury and dysfunction were defined as a pathology/injury/trauma of the joint, muscle, ligament, tendon, bone or nerve. This could be physician/physiotherapist/clinician-diagnosed or self-reported in this instance. We planned to assess the prevalence of musculoskeletal disorders and injury profile of retired ballet dancers. Given their cessation of dancing at the time of assessment, the 'exposure' of dance is removed. Therefore only prevalence data could be used to provide an estimate of musculoskeletal disorder profile as 'new' musculoskeletal injuries related to dance, would not occur.

Study design: We included case-control and cohort study designs. Single-case study papers were excluded. No restriction was placed on the language of paper or date of publication.

Identification of Papers

Based on the eligibility criteria above, two reviewers (TS, LD) independently reviewed the titles and abstracts from potentially relevant papers. The full texts of all potentially eligible papers were reviewed by each reviewer (TS, LD) independently before making a final decision on eligibility.

Data Extraction

We entered data onto a pre-defined data extraction table. Data extracted included: characteristics of ballet dancers including age at cohort inception and follow-up; gender; duration and level of ballet participated at; presence (and degree) of joint hypermobility (frequently assessed using the Beighton scoring system); and subsequent findings on location of pathology. This was performed by one reviewer (TS) and was verified by a second (LD). Any disagreements in data extraction were resolved through discussion between the two reviewers.

Outcome Measures

The primary outcome measurement was the incidence or period prevalence of musculoskeletal injury in ballet dancers.

Secondary outcome measurements included: the incidence or period prevalence of different musculoskeletal injuries experienced by ballet dancers; the incidence or period prevalence of specific anatomical regions affected by musculoskeletal injuries in ballet dancers; and the prevalence of chronic musculoskeletal disorders in ballet dancers once they had retired from ballet.

Critical Appraisal

Each included paper was critically appraised using the CASP 'Cohort Study' tool (CASP, 2015). This tool was justified since it has been widely adopted for reviews of previous musculoskeletal studies (Smith, Walker, & Russell, 2007; Postle, Pak, & Smith, 2012; Reilly, Barker, & Shamley, 2006). Each included paper was reviewed by one reviewer (TS) and independently verified by a second (LD). Quality was judged as scores of 10 to 13 (high quality), seven to nine (moderate quality), zero to six (low) as per Hosny et al's (2014) recommendations.

Any disagreements in study eligibility, data extraction or study appraisal score were discussed and resolved through a third reviewer who adjudicated (AM).

Data Analysis

Study method heterogeneity was assessed visually using the data extraction tables. Through this cohort characteristics and data collection methods were evaluated for between-study consistency. If heterogeneity was evident, we performed a qualitative narrative review of the trends in results. If study method homogeneity was evident in participant characteristics, follow-up period and data collection methods, a meta-analysis was undertaken to pool incidence data (number of new cases which developed musculoskeletal injuries within a given period of time) or period prevalence (number of cases with a musculoskeletal injury event within a period) data using a random or fixed effect effects meta-analysis model dependent on statistical heterogeneity. Such heterogeneity was evaluated using the Chi-squared and I-squared statistical tests. When $p>0.10$ and I-squared ≥20% a random-effects model was undertaken. When $p<0.10$ and I-squared <20% a fixed–effects model was employed.

A specific subgroup analysis was planned to analyse the incidence or period prevalence values for professional (defined as those where ballet was their principal occupational) or pre-professional dancers (defined as dancers in a dance school where the expectation was they could become professional dancers once older) versus recreational (defined as where ballet was not the principal occupation for the individual) ballet dancers.

All statistical analyses were conducted on RevMan (Review Manager (RevMan) [Computer program]. Version 5.1. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2011).

Results

Search Strategy Results

The results of the search strategy are presented in **Figure 1**. A total of 427 citations were identified. Of these, 51 were considered eligible on first review. On full-text assessment, 19 satisfied the eligibility criteria and were included in the review.

Methodological Quality

The results of the critical appraisal are presented in **Supplementary Table 2**. This demonstrates that the methodological quality was considered 'moderate' as recommended by Hosny and colleagues (2014) interpretation as CASP scores ranged from seven to nine points. Recurrent strengths to the evidence-base included clearly identifying the research question and adopting an appropriate design to answer that question (n=19; 100%), characterizing how the cohorts recruited (n=13; 68%) and accurately measuring injury frequency in a defined fashion in 17 papers (89%). The results also appeared believable of a cohort which is generalizable to the clinical setting, and were appropriately and accurately reflected against the previous evidence (n=19; 100%). However, only one study acknowledged important confounders which may have influenced the result e.g. duration of injury, type of activity, previous musculoskeletal disorders, hypermobility, co-morbidities (Allen et al., 2012). Only one studies reported injury data over a sufficient period of time (arbitrarily defined as 12 months in this instance) (Briggs et al, 2009), whilst only two studies assessed a sufficient enough cohort (arbitrarily defined as 85% of the original sampling frame e.g. dance company or cohort) to allow valuable assessments of the cohort's injury patterns (Briggs et al, 2009; Liederbach, Dilgen, & Rose, 2008).

Characteristics of Included Studies

A summary of the participant characteristics is presented in **Table 1**. From the 19 papers, 2815 ballet dancers were reviewed. This included 899 females and 177 males; two papers did not present the gender mix of their cohorts (Menetrey & Fritschy, 1999; Solomon et al., 1999). The ages of the cohort participants ranged from nine years (Gamboa et al, 2008) to 47 years (Ramel & Moritz, 1994; Ramel, Moritz, & Jarnlo, 1999; Klemp & Learmonth, 1984). The mean age of the cohorts was 20.9 years. Twelve studies presented the data from professional dancers (Allen et al., 2012; Briggs et al., 2009; Liederbach et al., 2008; Menetrey & Fritschy, 1999; Solomon et al., 1999; Ramel & Moritz, 1994; Ramel et al., 1999; Klemp & Learmonth, 1984; Bowling, 1989; Byhring & Bo, 2002; Kadel, Teitz, & Kronmal, 1992; McNeal et al., 1990) whilst four presented data on pre-professional ballet dancers (Gamboa et al, 2008; McNeal et al, 1990; Leanderson et al, 2011; Luke et al, 2002). Follow-up within the cohorts ranged from five months (Byhring & Bo, 2002) to 10 years (Klemp & Learmonth, 1984).

(1) What is the incidence or period prevalence of musculoskeletal injury in ballet dancers?

In total, 7332 injuries were reported in 2617 ballet dancers. No studies presented data on the incidence of musculoskeletal injuries in their cohorts of ballet dancers. The period prevalence of musculoskeletal injury was 280% (95% CI: 217% to 343%) on pooled meta-analysis from 19 studies. Pre-professional ballet dancer's pooled period prevalence was 104% (95% CI: 30% to 178%). Period prevalence in professional ballet dancers was 463% (95% CI: 336% to 590%) on meta-analysis.

(2) What are the most frequent types of musculoskeletal injuries experienced by ballet dancers?

Table 2 presents the pooled period prevalence data reported the frequency of musculoskeletal disorders by individual anatomical region. This suggests that the most frequently reported musculoskeletal conditions included hamstring strain (pooled period prevalence 51%; 95% CI: -90% to 192%; n=98), tendinopathy of muscles contributing to ankle motion (referred to ankle tendinopathy) (pooled period prevalence: 19%; 95% CI: -53% to 91%; n=904) and generalized low back pain (pooled period prevalence: 14%; 95% CI: -6% to 34%; n=1311). For the subgroup of professional dancers (**Supplementary Table 3**), there was a notably high period prevalence for metatarsal stress fracture (pooled period prevalence: 63%; 95% CI: -148% to 274%; n=54), tibial stress fracture (pooled period prevalence: 22%; 95% CI: -103% to 147%; n=54) and glutei/hip muscle spasm (pooled period prevalence: 13%; 95% CI: -18% to 44%; n=511). There were no particular pathologies that demonstrated a high period prevalence in the pre-professional cohorts (**Supplementary Table 4**).

(3) Which are the most frequent anatomical regions affected by musculoskeletal injuries in ballet dancers?

Table 3 presents the pooled period prevalence data on musculoskeletal disorders by anatomical region. This suggests the highest period prevalence of injury by region was for foot and toes (pooled period prevalence: 2.5%; 95% CI: 4% to 46%; n=2171), ankle (pooled period prevalence: 21%; 95% CI: 4% to 38%; n=2793), whilst the cervical spine (pooled period prevalence: 24%; 95% CI: -8% to 56%; n=910) and lumbar spine (pooled period prevalence: 17%; 95% CI: 1% to 33%; n=2572) presented with high prevalence data. On subgroup analysis, the professional ballet dancers (**Supplementary Table 5**) demonstrated a similar trend with highest pooled prevalence data for injuries to the lumbar spine (pooled period prevalence: 30%; 95% CI: -2% to 62%; n=1130), cervical spine (pooled period prevalence: 24%; 95% CI: -8% to 56%; n=910) and the foot/toes (pooled period prevalence: 19%; 95% CI: -13% to 51%; n=694). Whilst the pre-professional ballet dancer cohort (**Supplementary Table 6**) also demonstrated the highest period prevalence data for injuries to the foot/toes (pooled period prevalence: 29%; 95% CI: -21% to 79%; n=438). The second highest period prevalence was for injuries to the knee joint (pooled period prevalence: 17%; 95% CI: -15% to 49%; n=656).

(4) What is the prevalence of chronic musculoskeletal disorders in ballet dancers once they retire from ballet?

There were no data on the presentation of different musculoskeletal disorders or regions specifically from ballet dancers following their retirement from dancing. All data pertained to ballet dancers were on those still actively engaged in dancing.

Discussion

The findings of this review indicate that foot and ankle pathologies appear to be the most common injuries for professional and pre-professional ballet dancers whilst in active participation. The most common injuries experienced are tibial and metatarsal stress fractures in professional ballet dancers. No studies have reported the prevalence of chronic musculoskeletal disorders in ballet dancers once they have retired from active dancing.

The findings of this review suggest that predictive models maybe developed to be able to identify which subgroups of people may be at greatest risk of developing musculoskeletal dysfunction. The results highlight a high prevalence for foot and ankle, hamstring and spinal injuries. Therefore analyzing performance and training programmes to reduce musculoskeletal injuries to these regions is warranted. If results are suggestive, this latter research may therefore help in counseling and training people at risk of developing short and longer-term complications. Whilst participating in ballet. However, no studies were identified examining *why* specific injuries occurred in relation to certain training or performance requirements and activities. It therefore remains unclear from this work whether there is a relationship between certain maneuvers or types of ballet, and specific injury patterns. Further research on this and how preventative programmes may impact as a result, would be a valuable addition to the evidence.

Whilst the review highlighted the most frequently affected anatomical regions by specific musculoskeletal diseases, it did not investigate strategies which may be associated with reducing incidence of injury. Previous studies have suggested strategies such as sprung and even floors, warmer studios and awareness of the need of active rest and training programmes specific to the musculoskeletal capabilities of dancers may be possible strategies (Bowling, 1989). Awareness of such strategies has become more apparent in the past 20 years. Therefore assessing cohorts of dancers who were performing at the highest levels 30 or 40 years ago may provide different results from those in the past 10 years. The results can be used to inform rehabilitation and training regimes to focus on these “at risk” anatomical regions. Previous studies have suggested that injury prevention strategies, working towards optimizing proprioceptive and core-stability capabilities, can be important in reducing the risks of injury (Hincapie et al., 2008; Gamboa et al, 2008). By focusing on these regions, it is hoped that injury prevention can be further considered, and screening programmes for these regions may better identify early injuries for better management. This would therefore have a benefit to the dancer and the dancer’s organization in minimizing lost performance time, but also on the psychological impact and adverse events on career development, which injury can have on a dancer’s life (Ekegren et al., 2014).

Two of the included papers specifically assessed the impact of joint hypermobility on injury prevalence (Briggs et al., 2009; Gamboa et al., 2008). Briggs et al (2009) reported the prevalence of joint hypermobility (JHS) as assessed by skin hyperextensibility and joint dislocation as 33% of females and 32% in males. They reported that as well as presenting with a greater risk of injury, JHS may impact on the prognosis in professional ballet dancers (Briggs et al., 2009; Klemp & Learmonth, 1984). It is unclear whether this was related to ballet dancers who have JHS take longer to heal, or whether their soft tissue injuries are of greater severities compared to their non-JHS counterparts. Monitoring of this subgroup of the ballet dancing community may therefore be of particular importance.

The results of the professional versus pre-professional ballet dancer’s data suggest that the injury patters are largely similar, with foot and ankle and spinal pathologies being predominant. The injury patterns in pre-professional dancers are important to understand as a high proportion of professional dancers report the development of chronic injury before the age of 18 years, leading to early retirement (Lewis, Dickerson, & Davies, 1997). Therefore dancers should be well–managed in order to avoid injury at pre-professional stage to avoid such consequences.

The objective of this review was to identify the incidence or prevalence of specific musculoskeletal disorders in those participating in ballet dancing. No studies presented data on the incidence of musculoskeletal injuries in professional ballet dancers; all data was period prevalence data. Whilst there has been a body of literature to permit the first objective, it was not possible to ascertain the prevalence of specific musculoskeletal pathologies in people once they have retired from ballet at professional or recreational levels. This is a major limitation, as it is still unclear whether the activities associated with ballet have a longer-term impact on ballet dancer's musculoskeletal health. Further study is therefore warranted to firstly determine the prevalence of chronic musculoskeletal disorders in this population.

Whilst this paper provides evidence on injury profiles in professional ballet dancers, there are some limitations which should be considered. Firstly, due to the presentation of the data from the original papers, it was not possible to determine the 'actual' risk of injury per year or per 1000 dancers. The dataset did not permit the adjustment for time over the different study periods, but provided data to determine a period prevalence estimate across the studies. Secondly, there appears some variability in the reporting of injuries with some studies presenting self-reported injuries compared to injuries diagnosed by a medical team. This variability in injury reporting may have under- or over-estimated the true injury prevalence from the reviewed dancers. Finally, a number of the papers only focused on specific injuries, such as hamstring injuries in Askling et al (2002) and lower limb injuries only in McNeal et al (1990). Accordingly there may be under-representation of some injuries since these have yet to be fully reported. Finally, the papers poorly reported important confounding variables which may have impacted on the interpretation of the results. Factors such as training load, number of performances, age when commenced pre-professional and professional ballet and specifically on the type of ballet performed, may all influence injury incidence and profile. Based on these limitations, further study exploring the time-adjusted 'actual' risk of injury for all potential musculoskeletal injuries reported using valid and reliability physical examination methods, from an objective assessor with all important baseline epidemiological data captured, would be a valuable addition to the evidence-base.

Conclusion

This paper has identified which regions and what musculoskeletal disorders are most common in this challenging population. This can better inform clinicians, trainers, teachers and ballet dancers on which conditions and joints are most at risk of injury to inform current injury screening programmes. However, the long-term injury impact on developing chronic musculoskeletal disorders in retired ballet dancers remains unknown.

Highlights

- Ballet dancers are highly trained athletes who are at significant risk of musculoskeletal injury.
- The most frequent anatomical regions injured by ballet dancers are: ankle and foot, lumbar and cervical spine.
- No data has reported on the prevalence of chronic musculoskeletal disorders in retired ballet dancers.

Figure and Table Legends

Table 1: Characteristics of Included Studies

Table 2: Prevalence of injury by region

Table 3: Prevalence of injury by pathology

Figure 1: PRISMA Flow Chart

Supplementary Table 1: Search strategy for MEDLINE search

Supplementary Table 2: Table summarising the results of the CASP cohort critical appraisal of all cohort study design papers.

Supplementary Table 3: Prevalence of injury by region for professional dancers

Supplementary Table 4: Prevalence of injury by region for pre-professional dancers

Supplementary Table 5: Prevalence of injury by pathology for professional dancers

Supplementary Table 6: Prevalence of injury by pathology for pre-professional dancers

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Figure 1: PRISMA Flow Chart

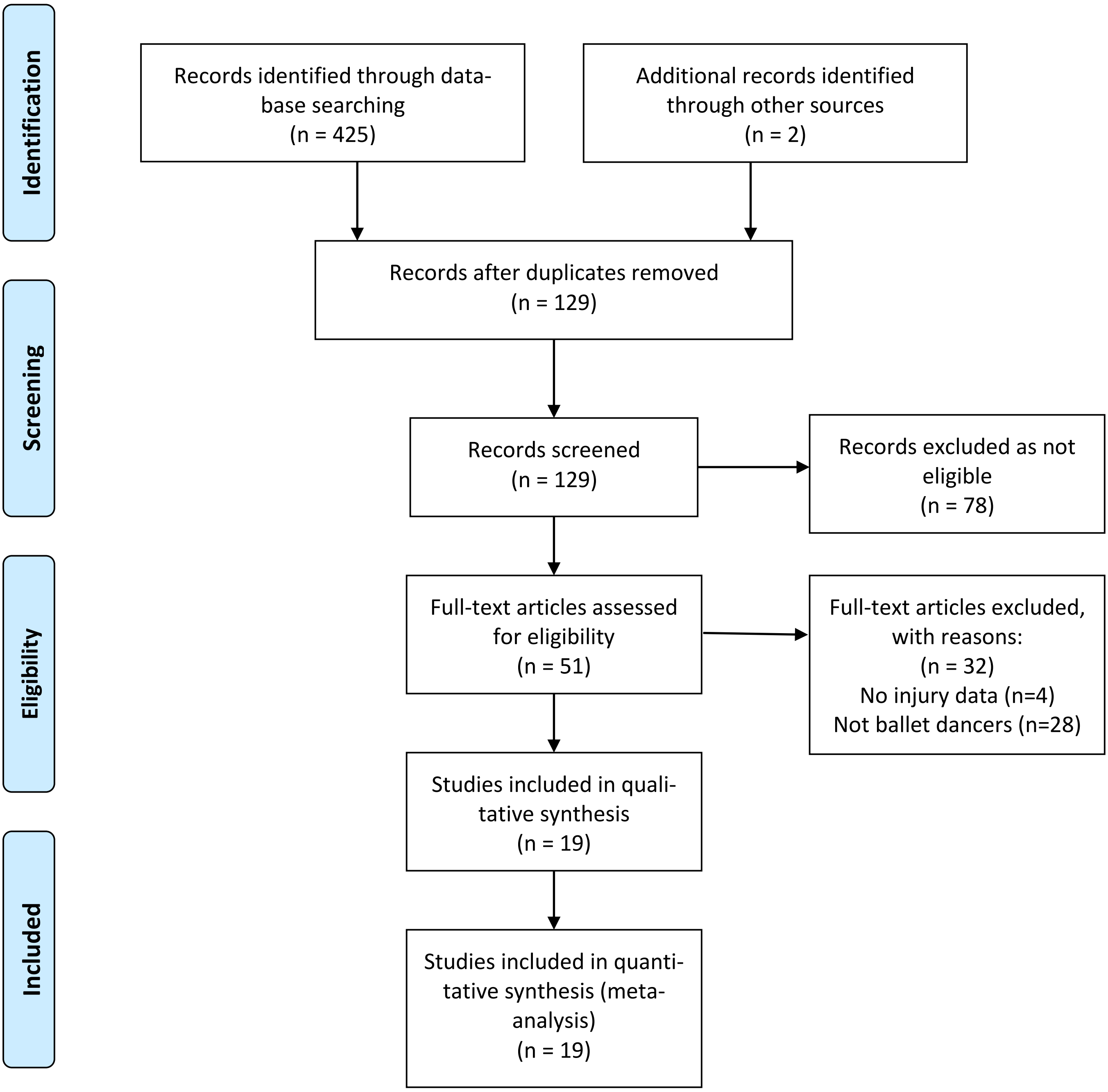

Table 1: Characteristics of Included Studies

Study	Sample Size	Gender (m/f)	Mean Age (range)	Assessment Timeframe	Frequency of injury and pathology and/or location of injury
Allen (2012)	52	25/27	24 (range not presented)	12 months	Total injury numbers: 355 Cervical facet joint pathology (25); neck muscle spasm (13); shoulder muscle spasm (6); thoracic facet joint (21); thoracic muscle spasm (5); lumbar facet joint (17); lumbar muscle spasm (24); glutei/hip muscle spasm (13); thigh muscle spasm (39); internal derangement knee (24); peroneal teninosis (4); medial tibial stress syndrome (22); stress fracture tibia/metatarsal (4); tibialis posterior tendinosis (14); achilles tendinopathy (1); calf muscle spasm (24); ankle instability/sprain (22); ankle impingement (8); foot muscle spasm (16); first meta-tarsal joint pain (9)
Askling (2002)	98	22/79	17-25	N/S	Total injuries: 98 Hamstring injury (50): Acute hamstring injury (33), chronic hamstring injury (17)
Bowling (1989)	141	61/80	N/S	6 months	Chronic Injuries (total 65): Back/neck (19); ankle (13); knee (11); thigh/leg (10) foot/toes (4) upper limb (4) Injuries in previous 6 months (total 58): back/neck (15); ankle (11); knee (7); thigh/leg (6); foot/toes (9); upper limb (3).
Briggs (2009)	93	55/38	N/S	5 years	Multiple joint pains (43/29); neck pain (24/19); dorsal pain (25/14); LBP (39/20); dislocations (4/3); ankle strains (25/15); one or more ligament injury (19/11); shoulder capsulitis (3/4); fractures (10/14)
Byhring and Bo (2002)	41	14/27	26.7 (19-40)	5 months	Total injuries: 31 dancers were injured
Ekegren (2014)	226	112/154	17.2 (15-23)	7 years	Total injury number: 410; Ankle tendinopathy (27); Ankle impingement (33); tenoperiostitis of tibia (33); tibial stress fractures (5); Meniscal injury (3); lumbar disc prolapse (5); Foot stress fracture (15); tibial stress fracture (5)

Gamboa (2008)	204	71/288	14.7 (9-20)	12 months	Total number of injuries (198). Foot and ankle (106); hip (43); knee (32); back (19)
Hamilton (1992)	29	15/14	22-41	N/S	Major injuries (females – 6; males – 9); Minor injuries (females 8; males 6); Overuse syndrome (females 11; males 8); stress fractures (females 4; males 3)
Kadel (1992)	54	0/54	N/S	N/S	Lifetime: (17 injuries); Stress fractures metatarsal (34); tibial stress fractures (12); spinal stress fractures (4).
Klemp (1984)	47	17/30	27.8 (19-47)	10 years	Total injury number: 156. Ankle sprain (35); knee ligament injury (14); ACL rupture (2); mid-tarsal sprain (5); low back pain (20); hip muscle strain/spasm (7); Quadriceps muscle spasm/strain (5); calf complex muscle spasm/strain (16); hip tendinopathy (4); knee tendinopathy (3); achilles tendinopathy (14); tibialis posterior tendinopathy (4) peroneus longus tendinopathy (1) hallus bursitis (2); extenso hallucis longus tendinpathy (2); flexor digitorum longus tendinopathy (4). Chondromalacia patellar 1; osgood schlatters (1); lateral meniscal injury (1)
Leanderson (2011)	476	179/297	14.5 (10-210	12 month	Total injury number: 438: Ankle sprains (50); Tendinosis pedis (56); Calcaneodynia (27); Plantar Fasciitis (19); Jumper's knee (31); patellar tendinitis (25); Chondromalacia patellae (25); Groin tendinitis (41); low back pain (45)
Liederbach (2008)	298	115/183	18-41	5 years	Total injuries 3721 over 5 years. 12 ACL injuries. 11 non-contact, 1 was contact derived. Foot and ankle (67); knee (7); hip (11); spine (14); upper extremity (4)
Luke (2002)	39	5/34	15.8 (14-18)	9 months	Total injuries (112). Acute injuries (22); recurrent injuries (17)
McNeal (1990)	350	64/286	N/S	N/S	Professionals: ankle (79); knee (56); foot (50)

					Pre-professional: ankle (74); knee (79); foot (44) College dancers: ankle (21); knee (20); foot (23) Young students: ankle (6); knee (5); foot (4)
Menetrey (1999)	60	N/S	N/S	12 months	Total injury (238). Subtalar subluxation (25); ankle injuries (43)
Nilsson (2001)	98	48/50	26.6	5 years	Total Injury 390; Fractures foot (16); ankle fracture (2); foot sprain (32); ankle sprains (62); foot stress fracture (8); foot and ankle tendinitis (101); peroneus (11); flexor hallucis longus (60); tibial posterior tendinoathy (19); Achillodynia (23); dorsal impingement (7); Anterior ankle impingement (8); retrocalcenal bursitis (15); metatarsalgia (14). Lower back pain (60) Site of pain: ankle/foot (210); lower leg (11); knee (43); thigh/groin (15); lower back (70); upper extremity (28)
Ramel and Moritz (1994)	64	26/38	17-47	12 months	Musculoskeletal pain: (60). Incapacitated by pain (44) Location of pain: low back (48); feet and ankles (39); neck (39)
Ramel et al (1999)	179	70/109	17-47	6 years	Musculoskeletal pain: (170). Incapacitated by pain (118) Location of pain: low back (125); feet and ankles (113); neck (97)
Solomon et al (1999)	68	N/S	N/S	5 years	Total injuries: (64); location: ankle (14), foot/toes (12); hip/thigh (9), low back pain (8). Sprains, strains, tendinopathy (33)

F- Female; LBP – Low Back Pain; M – Male; N/S – Not Stated

Table 2: Prevalence of injury by region

Anatomical Region	Regional injuries/Total injuries	Prevalence (95% CI)
Lumbar spine	440/2572	0.17 (0.01 to 0.33)
Thoracic spine	44/676	0.07 (-0.13 to 0.27)
Cervical spine	217/910	0.24 (-0.08 to 0.56)
Shoulder	13/676	0.02 (-0.09 to 0.13)
Hip	128/1314	0.10 (-0.07 to 0.27)
Thigh/leg	69/972	0.07 (-0.10to 0.24)
Knee	383/2471	0.15 (0.00 to 0.30)
Tibia/Calf	105/1371	0.08 (-0.07 to 0.23)
Ankle	576/2793	0.21 (0.04 to 0.38)
Foot/Toes	545/2171	0.25 (0.04 to 0.46)

CI: Confidence Interval

Table 3: Prevalence of injury by pathology

Pathology	Injuries/Total injuries	Prevalence (95% CI)
Lumbar facet joint dysfunction	17/355	0.05 (-0.18 to 0.28)
Generalised LBP	184/1311	0.14 (-0.06 to 0.34)
Lumbar spine muscle spasm	24/355	0.07 (-0.21 to 0.36)
Lumbar disc prolapsed	5/410	0.01 (-0.09 to 0.11)
Thoracic spine muscle spasm	5/355	0.01 (-0.09 to 0.11)
Neck muscle spasm	13/355	0.04 (-0.17 to 0.25)
Cervical joint dysfunction	25/355	0.07 (-0.21 to 0.35)
Shoulder muscle spasm	6/355	0.02 (-0.31 to 0.17)
Glutei/Hip muscle spasm	20/511	0.13 (-0.18 to 0.44)
Hip/groin tendinopathy	45/594	0.08 (-0.15 to 0.31)
Tight muscle spasm	44/511	0.09 (-0.17 to 0.35)
Hamstring injury	50/98	0.51 (-0.90 to 1.92)
Knee internal derangement	30/921	0.03 (-0.08 to 0.14)
Knee tendinopathy	59/594	0.10 (-0.15 to 0.35)
Knee collateral ligament injury	14/156	0.09 (-0.38 to 0.56)
Osgood schlatters	1/156	0.01 (-0.15 to 0.17)
Chrondromalacia patella	26/594	0.04 (-0.12 to 0.20)
Peroneal tendinopathy	49/1317	0.04 (-0.07 to 0.15)
Tibial stress fracture	17/464	0.04 (-0.14 to 0.22)
Calf muscle spasm	40/511	0.08 (-0.17 to 0.33)
Achilles tendinopathy	38/904	0.04 (-0.09 to 0.17)
Ankle Fracture	2/390	0.01 (-0.09 to 0.11)
Ankle instability/sprain	170/1345	0.13 (-0.06 to 0.32)
Ankle impingement	49/1611	0.03 (-0.05 to 0.11)
Subtalar subluxation	25/238	0.11 (-0.31 to 0.53)
Ankle tendinopathy	27/140	0.19 (-0.53 to 0.91)
Retrocalcaneal burisitis	15/396	0.04 (-0.16 to 0.24)

Tibialis posterior tendinopathy	37/907	0.04 (-0.09 to 0.17)
Medial tibial stress syndrome	22/355	0.06 (-0.19 to 0.31)
Metatarsal stress fracture	58/840	0.07 (-0.11 to 0.25)
Foot muscle spasm	16/355	0.05 (-0.18 to 0.28)
Hallus bursitis	2/156	0.01 (-0.15 to 0.17)
1st metatarsal joint pain	23/751	0.03 (-0.09 to 0.15)
Midtarsal sprain	37/546	0.07 (-0.15 to 0.29)
Flexor digitorium or halluces longus tendinopathy	4/156	0.03 (-0.24 to 0.30)
Flexor hallucis longus tendinopathy	60/396	0.15 (-0.23 to 0.53)
Extensor hallucis longus tendinopathy	2/156	0.01 (-0.15 to 0.17)

CI: Confidence Interval; LBP – Low Back Pain