CHRISTOPHER T.V. SWAIN, MSc[1] • ELIZABETH J. BRADSHAW, PhD[2,3]
CHRISTINA L. EKEGREN, PhD[4] • DOUGLAS G. WHYTE, PhD[1]

The Epidemiology of Low Back Pain and Injury in Dance: A Systematic Review

Dance is a physical pursuit that boasts high global popularity. In Australia, it has the highest participation rate for all cultural, sporting, and leisure activities among girls, and the second highest participation rate for children of both sexes.[5] In the United States, dance is estimated to account for 39% of the total moderate to vigorous physical activity achieved by adolescent girls and 23% of the total achieved by adolescent boys.[55]

The physically demanding nature of dance has been well documented. Students from preprofessional ballet schools in the United Kingdom complete more training hours than commonly reported by other adolescent athlete populations.[21] Australian professionals, including both company and independent dancers, typically complete in excess of 30 dance-hours per week in class, rehearsal, and performance, which they often manage alongside multiple other roles within the dance industry.[81] Moreover, it has been established that dancers are vulnerable to a high degree of musculoskeletal pain and injury,[35,39,42] a significant proportion of which includes pain and injury in the lower back.[58]

Observational studies have documented high prevalence rates of low back pain (LBP) in contemporary and ballet dancers, which has been associated with activity modification, care seeking, and medication use.[76,77] Furthermore, LBP and low back injury (LBI) have been identified as common and often severe causes of time-loss injury in both preprofessional and professional dancers.[4,21] This problem has been attributed to the unique and highly physical movement demands of dance.[56,59] Indeed, spinal pathologies such as spondylolysis, a defect caused by alternating full flexion and extension movements,[1] are more common in ballet dancers than in the general population.[65] Further, the incidence of spine stress fractures in professional ballet dancers appears to increase with dance-hours completed.[40]

Due to the heterogeneous injury definitions and reporting methods used in dance injury surveillance studies,[42,46,75] and the complexities of assessing pain and chronic injury outcomes,[6] determining the extent to which LBP and LBI are a problem in dance is not straightforward. Therefore, to advance the understanding of LBP and LBI in dance, the primary aim

BACKGROUND: Dance is a physical pursuit that involves loading the spine through repetitive dynamic movements and lifting tasks. As such, low back pain (LBP) and low back injury (LBI) have been identified as common health problems in contemporary and classical ballet dancers. However, clarity regarding the experience of LBP and LBI in dance is lacking.

OBJECTIVES: To systematically review and synthesize the epidemiology of LBP and LBI in dance populations.

METHODS: A comprehensive search of 6 electronic databases, back catalogs of dance science–specific journals, and reference lists of relevant articles and a forward citation search were performed.

RESULTS: Fifty full-text articles were included in the final systematic review. There was considerable methodological heterogeneity among the included studies. The median (range) point, yearly, and lifetime prevalence of LBP was 27% (17%-39%), 73% (41%-82%), and 50% (17%-88%), respectively. The lower back contributed to 11% (4%-22%) of time loss and 11% (5%-23%) of medical-attention injuries.

CONCLUSION: Dancers are vulnerable to LBP and LBI. The use of definitions that are sensitive to the complexity of LBP and LBI would facilitate improved understanding of the problem within dance, inform health care strategies, and allow for monitoring LBP-specific intervention outcomes.
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[1]School of Behavioural and Health Sciences, Australian Catholic University, Fitzroy, Australia. [2]Centre for Sport Research, School of Exercise and Nutrition Sciences, Deakin University, Burwood, Australia. [3]Sports Performance Research Institute New Zealand, Auckland University of Technology, Auckland, New Zealand. [4]Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia. The review was registered via PROSPERO (CRD42017073428) prior to commencement. Christopher Swain was supported by a Research Training Program Scholarship. Dr Ekegren is supported by a National Health and Medical Research Council of Australia Early Career Fellowship (GNT1106633). The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Christopher TV. Swain, School of Behavioural and Health Sciences, Australian Catholic University, Locked Bag 4115, Fitzroy, Melbourne Dc, VIC 3165 Australia. E-mail: chris.swain@acu.edu.au

of this review was to systematically assess the available evidence on the prevalence and incidence of LBP and LBI in preprofessional and professional dance populations. A secondary aim was to identify any risk factors in these populations for LBP and LBI.

METHODS

This systematic review is structured in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[52] The review was registered via PROSPERO (CRD42017073428) prior to commencement.

Search Strategy

Relevant publications were identified through systematic searches of the following 6 electronic databases up until June 25, 2018: MEDLINE, SPORTDiscus, Web of Science, Embase, CINAHL, and the ProQuest Performing Arts Periodicals Database. The search strategy included a combination of controlled vocabulary (eg, Medical Subject Headings of the National Library of Medicine) and free-text terms (**TABLE 1**). In addition, the Online Dance Medicine and Science Bibliography, back catalogs of dance-specific journals, including the *Journal of Dance Medicine and Science* and *Medical Problems of Performing Artists*, and reference lists from comprehensive reviews and identified studies were hand searched for possible references not otherwise found. Forward citation searching via Google Scholar was also performed. The search was limited to those articles published in English, but no date limits for publication were set.

Inclusion/Exclusion Criteria

Cohort or cross-sectional studies were included if they examined the prevalence and incidence of LBP/LBI in dancers, or risk factors for LBP/LBI in dancers, and met the following inclusion criteria. Studies of dancers of both sexes and all ages, including children participating in a structured dance program as well as adults dancing either at a tertiary or professional level, were eligible, but to control for current exposure, studies with only retired dancers were not. To ensure consistency in the type of physical exposure, dance styles including ballet, contemporary, modern, and dance theatre or similar were eligible, whereas other forms of artistic dance (eg, Irish dancing or salsa) or social forms of dance (eg, weddings) were excluded.

All possible definitions of pain and injury (eg, any complaint, medical consultation, disabling/time loss) and duration (eg, acute, chronic) were considered. However, the studies had to clearly report outcomes for the low back or lumbar spine region; studies reporting pain and injury to the back, spine, or lumbopelvic region were excluded. A risk factor was defined as any pre-existing factor that may increase the potential for LBP or LBI in dancers, and was identified through a prospective research design. Studies investigating factors associated with LBP/LBI cross-sectionally that were unable to describe whether the risk factor preceded the episode of pain were excluded from this component of the review. Studies that reported risk factors for injury but did not delineate the site of the injury were also excluded.

Data Extraction and Risk-of-Bias Assessment

Two reviewers (C.S. and E.B.) independently checked the titles and/or abstracts of all studies returned by the search results. Studies that were clearly not relevant were excluded. The full text of all subsequent studies was assessed to determine whether the selection criteria were met. Any disagreement between review authors was resolved through discussion. Data extraction and risk-of-bias assessment were performed by 2 reviewers (C.S. and D.W.) using a standardized, pre-piloted form. Extracted information included study details (authors, year, country, design, duration), participant information (dance style, level, sex, age, sample size), definition of pain/injury used, collection methods, LBP/LBI estimates (prevalence, incidence, etc), exposure variables (ie, risk factors), reported significance of associations between risk factors and LBP/LBI, and risk factors not significantly associated with LBP/LBI.

The classification of LBP/LBI estimates was dependent on the case definition and data-collection methods used by individual studies. Outcomes from studies that used a definition of pain were classified as LBP, whereas outcomes extracted from studies that used a definition of injury were classified as LBI. The risk-of-bias assessment was performed using a tool to assess risk of bias in prevalence studies (**APPENDIX**, available at www.jospt.org).[37] This tool contains 10 items that address external validity (selection and nonresponse bias) and internal validity (measurement and analysis bias).[37] Thus, each study received a score out of 10, with a lower score indicating a lower risk of bias. Risk-of-bias assessment was performed in relation to the assessment and reporting of LBP and LBI outcomes.

TABLE 1 MEDLINE Search Strategy and Results

Data Source	Search Strategy	Hits, n
MEDLINE Complete (EBSCO)	1. Dancing (MeSH) OR Danc* OR Ballet	13850
	2. Back pain (MeSH) OR Low back pain (MeSH) OR Spinal Injuries (MeSH) OR Athletic injuries (MeSH) OR Wounds and Injuries (MeSH) OR Back ache OR Lumbar pain OR Spin* pain OR Lumbago OR Sports Injur*	142841
	3. 1 AND 2	377
	4. Limit to English Language	330

RESULTS

The literature search returned a total of 4121 articles. Following duplication removal and a review of titles and abstracts, 144 full texts were screened, with 98 subsequently excluded. Fifty studies were included in the final review (**FIGURE**).

Description of the Studies

Of the studies included in this review, 22 were cross-sectional in design, 19 were retrospective, and 9 were prospective. Thirty studies presented data collected from a single cohort or medical center, and 20 included multiple cohorts. Ballet was the predominant style for 31 studies, contemporary or modern for 6, musical theatre for 2, and either a combination of styles or nonexclusive style was featured in 11 studies. Twenty-two studies featured professionals exclusively, 17 featured nonprofessionals, and 11 had a mix of professional and nonprofessional dancers. Descriptive data extracted from the included studies are represented in **TABLES 2** and **3**.

Risk of Bias

The median risk-of-bias score was 4.5/10. Five studies were judged to have a low risk of bias (deemed as 3/10 or less), which equated to 10% of the studies included in the final review. Studies with a low risk of bias commonly incorporated a tool with established reliability and validity to measure pain or injury (item 7), provided an adequate anatomical description of the low back (item 6), and obtained a sample that was judged to reflect a national dance population (item 1).

Prevalence of LBP

Fourteen studies[20,26,33,47,54,57,58,61,62,65,76-78,87] that reported LBP prevalence met the inclusion criteria for this review. Thirteen of these were cross-sectional and 1 was prospective. Multiple tools and LBP definitions were used. Seven studies reported point prevalence,[76,77] "pain now,"[87] "recent pain,"[78] or pain experienced in the last 7 days.[33,57,58] These studies reported a median (range) prevalence of 27% (17%-39%). Only 1 study[77] reported monthly prevalence of activity-limiting LBP (LBP that resulted in missed or modified dance practice), which was 22%. Six studies reported LBP experienced for an academic (9 months)[77] or full (12 months)[57,58,61,65,76] calendar year. These studies had a median (range) prevalence of 73% (41%-82%) for any LBP, and 33% (25%-52%) for LBP that was associated with activity limitation or disability. One study[77] identified a 24% prevalence of chronic LBP, which was defined as 3 consecutive monthly episodes of pain, recorded over a 9-month period. The lifetime history of LBP, reported by 6 studies,[26,47,62,65,76,87] ranged between 17% and 88% and had a median value of 50%. Using only estimates from studies with a low risk of bias had minimal impact on the median (range) values observed for point (27% [17%-39%]) and yearly (78% [70%-82%]) LBP prevalence.

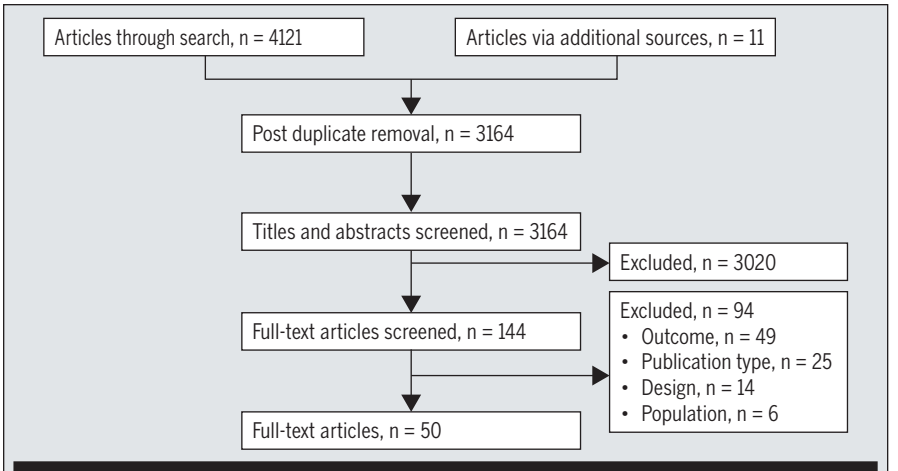

FIGURE. PRISMA flow chart.

Prevalence of LBI

Five studies reported the prevalence of LBI in dancers.[8,16,22,58,78] These used a range of designs, definitions, and time periods. The point prevalence of LBI that limited participation was 8% in a single study of predominantly professional contemporary dancers.[78] During a 7-month season, 25% of professional female dancers and 0% of male dancers experienced an LBI, although this was based on a sample of only 13 dancers (8 female).[8] Nineteen percent of West End performers reported experiencing an LBI during their current production, albeit with varied time periods of each production.[22] History of LBI in professional contemporary and ballet dancers was reported by 2 studies, and history of major LBI (causing more than 1 month away from dance) was reported by 1 study. These values were 23%,[16] 32%,[78] and 20%,[58] respectively.

Incidence of LBI

Only 2 studies reported incidence of LBI using a dance-exposure or dance-hour denominator. Incidences of 0.78 per 1000 dance-exposures and 0.53 per 1000 dance-hours were observed in ballet students.[9] Reported incidence in professional ballet dancers was 0.63 and 0.55 per 1000 dance-hours in females and males, respectively.[4]

LBP and LBI as a Percentage of All Injuries Experienced by Dancers

Thirty-three studies reported the percentage of all injuries sustained by dancers that were to the lower back. Of these, 11 studies (12 estimates) used a time- or activity-loss definition,[4,7,9,11,12,19,59,66,82,83,85] 16 studies (12 estimates) used a med-

ical-attention or medical-cost definition,[25,27-30,45,53,56,63,67-71,74,88] and 6 used a definition that was not dependent on time loss or medical attention.[19,43,44,72,84,86] The median percentage (range) was 11% (4%-22%) for studies that used a time-loss definition, 11% (5%-23%) for studies that used a medical-attention definition, and 12% (6%-21%) for studies that employed separate injury definition criteria. No studies that examined LBI scored a low risk of bias for this outcome. However, including only studies with a risk-of-bias score equal to or below the median (4.5 or less) had minimal impact on the median (range) of observed values for time-loss (10% [4%-20%]), medical-attention (12% [5%-18%]), or other (10% [9%-11%]) LBI incidence definitions.

The percentage of all injuries accounted for by the lower back was higher in studies that used professional cohorts exclusively rather than preprofessional cohorts. In preprofessional dancers, the median percentage (range) was 10% (4%-22%) in studies that used a time-loss definition[7,9,12,21] and 8% (5%-12%) in studies that applied a medical-attention injury definition.[28,45,63,74,88] In professionals, the median (range) was higher, at 13% (6%-20%) for time-loss definitions[4,11,59,66,82,83] and 14% (12%-23%) for medical-attention definitions.[29,53,67-71]

TABLE 2 Prevalence of LBP in Dance

Study	Study Type	Level of Evidence	Risk of Bias	Country	Cohort Description	n (% Female)	Age, y*	Definition of LBP	Collection Methods	LBP Prevalence Estimates, %
Drężewska and Śliwiński[20]	Cross-sectional	IV	6.5	Poland	1 ballet school	71 (63)	16.5 (15-18)	Pain measured via visual analog scale	Self-report	Period unclear: 62
Gamboa et al[26]	Prospective (LBP acquired cross-sectionally)	IV	4	United States	1 ballet school	359 (80)†	14.7 ± 1.9	"Subjective history with specific focus on LBP"	Part of medical history prescreening	Lifetime: 33
Grego Muniz de Araújo et al[33]	Cross-sectional	IV	2	Brazil	1 dance festival. Ballet and other. Professional and other	163 (77)	28.7 ± 9.8	Nordic musculoskeletal questionnaire	Self-report	Last 7 d: all, 39; female, 39; male, 38
Liederbach et al[47]	Cross-sectional	IV	6	United States	Schools and companies. Classically trained	947 (65)	18-35	"A history of chronic or recurrent LBP"	Self-report	History of chronic/recurrent LBP: all dancers, 17; dancers with scoliosis, 23
Nunes et al[54]	Cross-sectional	IV	6	Canada	2 dance studios. Young dance students	31 (100)	8-20	Pain identified on a body chart	Self-report	Last month: 8.3
Ramel and Moritz[57]	Cross-sectional	IV	1	Sweden	3 ballet companies	128 (59)	Female, 27 (18-43); male, 28 (17-47)	Nordic musculoskeletal questionnaire	Self-report	Past 12 mo: 70 Time loss in last 12 mo: 25 Past 7 d: 27
Ramel et al[58]	Cross-sectional	IV	2	Sweden	3 ballet companies	51 (67)	32 (28-37)	Nordic musculoskeletal questionnaire; major injury defined as one that stopped dance for more than 1 mo	Self-report	Past 12 mo: 82 Time loss in last 12 mo: 33 Past 7 d: 37 Major low back injury history: 19.6
Roussel et al[62]	Prospective (LBP acquired cross-sectionally)	IV	4	Belgium	1 preprofessional dance program	32 (81)	20 ± 2	Unspecified	Visual analog scale	History: 63
Roussel et al[61]	Cross-sectional	IV	4	Belgium	1 preprofessional dance program	40 (95)	20.3 ± 2.4 (17-26)	LBP for at least 2 consecutive days	Visual analog scale	Past 12 mo: 41
Seitsalo et al[65]	Cross-sectional	IV	4.5	Finland	1 ballet company	60 (58)‡	28 (21-43)	Any LBP, lumbago, sciatic pain, nonspecific LBP	Self-report	History: any LBP, 88; lumbago, 12; sciatic pain, 10 Past 12 mo: 76

Table continues on page 243.

Risk Factors for LBP and LBI

Only 2 studies assessed risk for LBP and adjusted for confounding variables.[76,77] Other studies performed only univariable analysis, or delineated LBP and injury outcomes based on a potential risk factor but did not perform statistical analysis on these variables. Studies that did perform univariable analysis lacked consistency in reporting the significance of associations between risk factors and LBP. They also did not present or interpret the magnitudes of any identified associations.

Seventeen studies examined sex as a risk factor for LBP and LBI, or delineated outcomes based on sex (**TABLE 4**).[4,7,12,16,30,33,57,65,67-70,76,77,82,84,85] No sex-related differences were reported in 11 studies.[12,33,57,65,67-70,76,77,84] One study observed a higher percentage of self-reported and a lower percentage of physical therapist–reported LBIs in male dancers compared to female dancers.[7] Four injury studies observed that male dancers experienced a greater percentage of injuries to the low back than female dancers.[16,30,82,85] One study observed a higher incidence of LBI in female dancers, although significance was not reported.[4]

Five studies tested for or delineated differences in age (**TABLE 4**).[20,30,76,77,87] The prevalence of LBP or proportion of LBI increased as the age of dancers increased in 3 studies.[20,30,87] Conversely, age was not associated with LBP prevalence in 2 studies that adjusted for confounding

TABLE 2 Prevalence of LBP in Dance (continued)

Study	Study Type	Level of Evidence	Risk of Bias	Country	Cohort Description	n (% Female)	Age, y*	Definition of LBP	Collection Methods	LBP Prevalence Estimates, %
Swain et al[76]	Cross-sectional	IV	4	Australia	1 ballet school, 2 contemporary universities, 1 ballet company	110 (83)	Female, 17.9 ± 2.6; male, 17 ± 3.6	Pain in the posterior aspect of the body, from the lower margin of the 12th ribs to the lower gluteal folds	Self-report	Point: all, 12; female, 25.3; male, 15.8 Past 12 mo: all, 64 History: all, 74; female, 78.9; male, 72.5
Swain et al[77]	Prospective (duration, 9 mo)	II	3	Australia	1 ballet school, 2 contemporary universities, 1 ballet company	119 (84)	Female, 17.9 ± 2.7; male, 17 ± 3.7	Pain in the posterior aspect of the body, from the lower margin of the 12th ribs to the lower gluteal folds Any episode, activity-limiting LBP (causes modification or missed class), chronic LBP (3 consecutive monthly episodes)	Self-report	9 mo Any LBP: all, 78; female, 78; male, 79 Activity-limiting LBP: all, 52; female, 54; male, 42 Chronic LBP: all, 24; female, 23; male, 32 Point prevalence: 8-25 Monthly prevalence: any LBP, 19-58; activity-limiting LBP, 11-34
Thomas and Tarr[78]	Cross-sectional	IV	5.5	United Kingdom	Student, professional, retired, and other. Predominantly contemporary dancers	204 (86)	16 to >45	Pain (subjective), injury: participation impact	Questionnaires and semi-structured narrative interviews	"Recent" LBP, 29.9; current low back injury, 8.3; past low back injury, 32.4
Wójcik and Siatkowski[87]	Cross-sectional	IV	2.5	Poland	Ballet students at the primary, junior high, and high school levels	237 (sex distribution not reported)	Primary, 11.2 ± 0.8; junior, 14.0 ± 0.8; high, 17.0 ± 0.8	Pain: a numeric rating scale	Self-report	Pain "now" All, 23.2; primary, 12.5; junior, 16.1; high, 46.9 Pain "before" All, 36.7; primary, 18.8; junior, 33.3; high, 64.1

Abbreviation: LBP, low back pain.
**Values are mean (range), range, mean ± SD, or mean ± SD (range).*
†Prevalence data available for n = 198.
‡Prevalence data available for n = 50.

TABLE 3 Prevalence and Incidence of LBI in Dance

Study	Study Type (Duration)	Level of Evidence	Risk of Bias	Country	Cohort Description	n (% Female)	Age, y*	Definition of LBI	Collection Methods	LBI Estimates
Allen et al[4]	Prospective (1 y)	II	3.5	United Kingdom	1 professional ballet company	52 (49)†	Female, 25 ± 6; male, 23 ± 5	Time loss	Physical therapist	Incidence, n (%) All, 47 (13.2); female, 26 (15.1); male, 21 (11.5) Incidence (per 1000 dance-h) Female, 0.63; male, 0.55
Baker et al[7]	Cross-sectional/ retrospective (9.5 mo)	IIIb	5.5	United Kingdom	1 contemporary dance school (first years)	57 (83)	Female, 20 ± 2.5; male, 21 ± 3	Time loss	Self-report and physical therapist records	Incidence, n (%) All, 6 (8.6); female, 3 (5.4); male, 3 (21.4) Physical therapist recorded All, 9 (14.3); female, 8 (15.4); male, 1 (9.1)
Berlet et al[8]	Prospective (7 mo)	II	5.5	United States	1 ballet company	13 (62)	Female, 26.89 ± 2.98; male, 28.83 ± 3.31	Time loss/ medical-attention grading	Self-report	Prevalence, % All, 15; female, 25; male, 0
Bowerman et al[9]	Prospective (6 mo)	II	5.5	Australia	1 ballet school	46 (65) 4 dropouts (1 female, 3 male)	16 ± 1.58	Time loss	Physical therapist	Incidence, n (%): 13 (22.0) Incidence (per 1000 dance-exposures): 0.78 Incidence (per 1000 dance-h): 0.53
Byhring and Bø[11]	Prospective (19 wk)	II	4.5	Norway	1 ballet company	41 (66)	Female, 26 ± 5.7; male, 27 ± 4.6	Combined time loss/ medical attention	Physical therapist	Incidence, %: ~7.5-8.5
Caine et al[12]	Cross-sectional/ retrospective (8.5 mo)	IIIb	3.5	Canada	1 ballet school	71 (62)	Female, 16.41; male, 17.37; all, 11-23	Time loss	Self-report	Incidence, n (%) All, 4 (3.5); female, 2 (2.8); male, 2 (4.7)
Costa et al[16]	Cross-sectional	IIIb	5	Brazil	2 professional ballet companies and controls	53 (59), 57 controls	Female, 34.2 ± 6.3; male, 34.1 ± 7.3	Injuries, regardless of time loss/ medical attention	Self-report	Prevalence, % Dancers: all, 22.6; female, 6.5; male, 45.5 Controls, 5.3
DiPasquale et al[19]	Prospective (4 mo)	II	6.5	United States	1 modern dance university program (not audition based)	46 (89)	19.61 ± 1.31	Injuries, regardless of time loss/ medical attention	Self-report	Incidence, n (%): 5 (10.9)
Ekegren et al[21]	Prospective (1 academic year)	II	3.5	United Kingdom	3 ballet schools	266 (58)	17.2 ± 1.21 (15-23)	Time loss	Physical therapists	Incidence, n (%): 36 (9.5)

Table continues on page 245.

TABLE 3 Prevalence and Incidence of LBI in Dance (continued)

Study	Study Type (Duration)	Level of Evidence	Risk of Bias	Country	Cohort Description	n (% Female)	Age, y*	Definition of LBI	Collection Methods	LBI Estimates
Evans et al[22]	Cross-sectional	IIIb	3.5	United Kingdom	Multiple West End productions	58 (64)	Female, 25.8 ± 5.4; male, 25.0 ± 5.4	Injuries, regardless of time loss/ medical attention	Self-report	Prevalence, %: 18.5
Fulton et al[25]	Retrospective (3 y)	IIIb	4.5	United States	Summer dance intensive. Modern and other styles. Recreational to professional	321 who sought care	(12-~50)	Medical attention	Clinic records	Incidence, n (%): 41 (10) for years 2-3 (year 1 NR)
Garrick[27]	Retrospective (5 y)	IIIb	5	United States	1 sports medicine clinic. Primarily treats professional and preprofessional ballet dancers	1055 injuries treated	No age restrictions	Medical attention	Physician/ sports medicine clinic records	Incidence, n (%): ~63 (6); 95 (9) involved the spine. Two thirds were the lumbar spine
Garrick and Requa[29]	Retrospective (3 y)	IIIb	5	United States	1 professional ballet company	~70 contracted dancers and 12 apprentices ~200 students covered for injuries sustained during performances or rehearsals with the company	NR	Medical expenses	Insurance documents and medical records	Incidence, n (%): 71 (23)
Garrick and Requa[30]	Retrospective (17 y)	IIIb	3.5	United States	1 sports medicine clinic with medical responsibilities for 2 professional companies and 1 preprofessional ballet school	3960 injuries treated (75)	11 to >26	Medical attention	Physician/ sports medicine clinic records	Incidence, n (%) All, 293 (7.4); female, 200 (6.5); male, 93 (10.6)
Garrick[28]	Retrospective (2 y)	IIIb	4	United States	1 ballet school	59	13-18	Medical attention	Medical records	Incidence, n (%): 9 (4.6)
Klemp and Learmonth[43]	Retrospective (10 y)	IIIb	4	South Africa	1 ballet company	47 (64)	27.8 (19-47)	Injuries, regardless of time loss/ medical attention	Workers' compensation records	Incidence, n (%) Ligament injuries, 6 (8.5); tendon injuries, 0 (0); muscle injuries, not possible to discern
Krasnow et al[44]	Cross-sectional	IV	5.5	Canada	Females from modern, ballet, and gymnastics	65 (100); 35 dancers, 30 gymnasts	15.5 ± 0.5 (12-18)	Injuries, regardless of time loss/ medical attention	Self-report	Incidence, % Ballet, 12; modern, 21; gymnast, 18

Table continues on page 246.

TABLE 3 Prevalence and Incidence of LBI in Dance (continued)

Study	Study Type (Duration)	Level of Evidence	Risk of Bias	Country	Cohort Description	n (% Female)	Age, y*	Definition of LBI	Collection Methods	LBI Estimates
Leanderson et al[45]	Retrospective (7 y)	IIIb	4	Sweden	1 ballet school	476 (62)	10-21	Medical attention	Medical records	Incidence, n (%) Female, 23 (5.3); male, 22 (5.1) of LBP diagnosis of all injuries
Nilsson et al[53]	Retrospective/ prospective (5 y)	II-IIIb	4.5	Sweden	1 ballet company	98 (51)	28.3 (17-47)	Medical attention	Physician records	Incidence, n (%): all, 60 (15)
Quirk[56]	Retrospective (15 y)	IIIb	6	Australia	1 professional ballet company and a ballet school	664 (71)	NR	Medical attention	Physician records	Incidence, n (%): 180 (8.5)
Ramkumar et al[59]	Retrospective (10 y)	IIIb	4.5	United States	1 professional ballet company	153 (53)	27.5	Combined time loss/ medical diagnosis	Workers' compensation and physician diagnosis	Incidence, n (%): 117 (20)
Rovere et al[63]	Retrospective (9 mo)	IIIb	4	United States	Ballet and modern dancers from 1 tertiary dance program	218 (74)	NR	Medical attention	Physician records	Incidence, n (%): 43 (12.2)
Shah et al[66]	Cross-sectional	IV	3.5	United States	National survey of professional modern dancers	184 (73)	30.1 ± 7.3 (18-55)	Time loss	Self-report	Incidence, n (%): 40 (17)
Sobrino et al,[67] Sobrino and Guillén[68]	Retrospective (5 y)	IIIb	4.5	Spain	4 professional ballet and contemporary ballet companies	145 (52)	All, 25.8 ± 5.7; female, 26.3 ± 5.9; male, 25.2 ± 5.4	Medical attention	Insurance records	Incidence, n (%): 49 (13.4)
Solomon and Micheli[72]	Cross-sectional	IV	5	United States	Multiple modern dance companies	164 (77)	26.15 ± 6.43 (16-48)	"Debilitating" injuries, regardless of time loss/ medical attention	Self-report	Incidence, n (%) All, 45 (15.3); Cunningham, 9 (14.3); Graham, 10 (16.3); Horton, 8 (21.6); Humphrey-Weidman, 2 (6.1); Limon, 16 (15.4)‡
Solomon et al,[69] Solomon et al,[70] Solomon et al[71]	Retrospective/ prospective (5 y)	II-IIIb	3.5	United States	1 ballet company	Year 1, 70 (57); year 2, 60 (NR); year 3, 60; year 4, 60; year 5, 59	All, 17-35	Reported injury that may or may not have required medical attention	Company records	Incidence, n (%) Year 1, 12 (8); year 2, 12 (8.4); year 3, 13 (13); 5-y average, 14 (12)
Stracciolini et al,[74] Yin et al[88]	Retrospective (9 y)	IIIb	4.5	United States	1 sports medicine clinic. Pediatric dancers	181 (95) 171 (100)	14.8 ± 2	Medical attention	Random sampling of medical charts of a sports medicine clinic	Incidence, % 11.5 11.7

Table continues on page 247.

TABLE 3 Prevalence and Incidence of LBI in Dance (continued)

Study	Study Type (Duration)	Level of Evidence	Risk of Bias	Country	Cohort Description	n (% Female)	Age, y*	Definition of LBI	Collection Methods	LBI Estimates
Wanke et al[85]	Retrospective (17 y)	IIIb	3.5	Germany	6 professional ballet companies and 1 state ballet school	Occupational accidents, 291 (63)	All, 30.1; female, 29.5; male, 30.8	Time-loss injuries attributed to dance floors	Work accident reports	Incidence, % Female, 4.2; male, 14.1
Wanke et al[84]	Cross-sectional	IV	5	Germany	1 musical theatre school	37 (46)	All, 21.3 ± 2.2; female, 21.1 ± 2.2; male, 21.5 ± 2.2	Injuries, regardless of time loss/ medical attention	Self-report	Incidence, n (%) All, 12 (13.2); acute, 3 (6.1); chronic, 9 (21.4)
Wanke et al[82]	Retrospective (17 y)	IIIb	3.5	Germany	3 ballet companies	Occupational accidents, 745 (48)	All, 28.7 ± 5.3; female, 28.9 ± 5.2; male, 28.5 ± 5.4	Time loss	Work accident reports	Incidence, % All, 8.5; female, 9.8; male, 17.3
Wanke et al[83]	Retrospective (2 y, 17 y apart)	IIIb	3.5	Germany	3 ballet companies	Occupational accidents, 241 (46)	1994/95: all, 28.0; female, 28.3; male, 27.7 2011/12: all, 29.5; female, 29.5; male, 29.5	Time loss	Work accident reports	Incidence, % 1994/95, 5.8; 2011/12, 20.3
Washington[86]	Cross-sectional	IV	7	United States/ international	International survey of dancers as well as medical and support staff	NR	NR	Injuries, regardless of time loss/ medical attention	Self-report	Incidence, n (%) Individual reports, 52 (12); group reports, 81 (6)

Abbreviations: LBI, low back injury; LBP, low back pain; NR, not reported.
**Values are mean (range), range, mean ± SD, or mean ± SD (range).*
†Injury analysis for 50 dancers only.
‡Some injuries were counted more than once if a dancer studied multiple dance styles.

variables, including factors related to sex and maturation, anthropometry, cohort type, and LBP history.[76,77] Years dancing was not associated with LBP prevalence in 3 studies.[20,76,77]

Additional exploration of risk factors included a history of LBP and anthropometric data (eg, height, body mass). History was a significant predictor for activity-limiting LBP in 1 study (adjusted odds ratio = 3.98; 95% confidence interval: 1.44, 11.00).[77] Higher prevalence of LBP history was observed in dancers with scoliosis, although statistical analysis was not performed.[47] A body mass index lower than 18.5 was associated with higher risk of LBP in 1 study,[20] but no association between LBP and height, body mass, or body mass index was observed in 2 studies using multivariable analysis.[76,77]

DISCUSSION

Findings

The purpose of this systematic review was to synthesize the epidemiology of LBP and LBI in pre-professional and professional dance populations. The median point (27%), yearly (73%), and lifetime (50%) prevalence of LBP observed in dancers were similar to or above rates that have been previously reported in the global population (18%, 48%, and 49%, respectively)[36] and in a meta-analysis of sub-elite to elite participants in Olympic sports (24%, 55%, and 61%, respectively).[79] These findings must be interpreted with substantial caution, as significant methodological heterogeneity was present among the included studies. Specifically,

there were inconsistencies in targeted populations, sex balance, study designs, time periods, anatomical definitions, and statistical reporting. A higher median yearly percentage than lifetime percentage highlights the difficulties in obtaining accurate estimates of LBP and emphasizes the importance of synthesizing results from a range of studies.

Comparison between studies that report LBP and those that report LBI is difficult. Studies of LBP used prevalence statistics more frequently compared to studies of LBI, which most often presented the frequency of LBI as a percentage of all injuries experienced by dancers. Nonetheless, studies included in the review indicated that approximately 73% of

TABLE 4 Association of Sex and Age With Low Back Pain and Low Back Injury in Dance

Risk Factor/Study	Observation	Reported Significance	Confounders Controlled for
Sex			
Allen et al[4]	Male less than female (11.5% versus 15.1%; 0.55/1000 dance-hours versus 0.63/1000 dance-hours)	Not reported	None
Baker et al[7]	Self-report: male greater than female (21.4% versus 5.4% Physical therapist records: male less than female (9.1% versus 15.4%)	Not reported	None
Caine et al[12]	Male equal to female (4.7% versus 2.8%)	Not reported	None
Costa et al[16]	Male greater than female (45.5% versus 6.5%)	$P<.01$	None
Garrick and Requa[30]	Male greater than female (10.6% versus 6.5%)	Not reported	None
Grego Muniz de Araújo et al[33]	Male equal to female (39% versus 38%)	Not reported	None
Ramel and Moritz[57]	Male equal to female. Delineated values not presented	"No significant difference in pain locations in men versus women." *P* value not reported	None
Seitsalo et al[65]	Spondylolysis prevalence: male equal to female (40% versus 26%)	$P = .08$	None
Sobrino and Guillén,[68] Sobrino et al[67]	Male equal to female (24% versus 25%)	Not reported	None
Solomon et al,[69] Solomon et al[70]	Male equal to female (9% versus 10%)	Not reported	None
Swain et al[76]	Point prevalence: male equal to female (16% versus 25%) Lifetime prevalence: male equal to female (73% versus 79%)	Point: AOR = 1.20; 95% CI: 0.19, 7.69; $P = .85$ Lifetime: AOR = 1.18; 95% CI: 0.26, 5.39; $P = .83$	Age, body mass, body mass index, cohort type, years dancing Age, height, body mass
Swain et al[77]	Male equal to female (42% versus 54%)	$P>.25$	None
Wanke et al[82]	Male greater than female (17.3% versus 9.8%)	"Significant gender (sic) specific differences were observed in the spine region … particularly with the more than twice affected lumbar spine in male dancers." *P* value not reported	None
Wanke et al[85]	Injuries to the lumbar spine that were attributed to dance floors were more common in male dancers (14.1%) than in female dancers (4.2%)	$P = .023$	None
Wanke et al[84]	Male equal to female. Delineated values not reported	"No statistically significant gender (sic) differences in the location of acute injuries were found." *P* value not reported	None
Age			
Drężewska and Śliwiński[20]	Older greater than younger	$P<.05$	None
Garrick and Requa[30]	Older greater than younger	Not reported	None
Swain et al[76]	Age not significant	Point: AOR = 1.06; 95% CI: 0.76, 1.48; $P = .71$ Lifetime: AOR = 1.11; 95% CI: 0.91, 1.40; $P = .31$	Sex, height, body mass, cohort type, years dancing Sex, height, body mass
Swain et al[77]	Age not significant	AOR = 0.99; 95% CI: 0.76, 1.29; $P = .93$	Age started dancing, cohort type, low back pain history
Wójcik and Siatkowski[87]	Older greater than younger	Not reported	None

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

dancers will experience at least 1 episode of LBP each year; however, the lower back will only be identified as the cause of time loss or medical attention for 11% of cases.

This disparity may be indicative of 2 realities. First, dancers experience many injuries at sites that do not include the lower back,[42] which in effect may lower the relative contribution of LBI to the total injury count. Second, the impact of an episode of LBP will often fall short of a time-loss or medical-attention threshold,[77] and many dancers may be able to maintain a high level of performance even in the presence of pain.[38] In this respect, traditional definitions of injury are only capable of providing a partial overview of the problem. This finding is consistent with observations from general,[24] sporting,[6] and dance populations.[41] For example, based on a review of 7 population studies, the pooled prevalence of care seeking in persons with LBP was 58%,[24] which indicates that medical records are not suitable for determining the overall prevalence of a condition. Based on current evidence, it is unclear whether this behavior is more pronounced in dancers compared to general and sporting populations.

Consistent with previous reviews of pain and injury in dance,[35,39,42] significant heterogeneity of definitions among the studies included was observed. For example, for time-loss injuries, collection methods included self-report[7,66] as well as health professional registration,[4,7,9,21,82,83,85] and the minimum threshold for registration included activity modification or partial absence,[7,9,11,12,66] complete absence for at least 1 day,[4,21,59] or time-limiting incident without a threshold defined.[82,83,85] Furthermore, the interpretation of severity varied between studies that used a time-loss definition. For instance, Bowerman et al[9] used 3 levels to classify injury severity in preprofessional ballet students: (1) modified class, (2) off class for up to 3 days, (3) off class for more than 3 days. In contrast, in professional ballet dancers, Allen et al[4] categorized injuries as transient (return within 7 days), mild (return after 7 to 28 days), moderate (return within 29 to 84 days), and severe (return after 84 days).

A second aim of the review was to identify risk factors for LBP and LBI. Overall, few studies deliberately focused on risk factors, and, collectively, interpreting factors associated with LBP and LBI was limited by an absence of appropriate statistical analysis and magnitude-based statistics. One prospective cohort study indicated that a history of LBP was a significant predictor of future episodes of activity-limiting LBP.[77] This is in accord with LBP literature, which has consistently described history as a primary contributor toward future LBP.[2,23] The implication is that LBP is rarely limited to a single episode.

The prevalence of LBP and percentage of all injuries located in the lower back appeared to increase with age and dance level.[20,30,87] However, multivariable statistical analyses have not yet demonstrated a significant relationship between age, years of training, or dance level and LBP.[76,77] As a relationship with age and dance level may provide important information about biological or workplace factors that contribute to LBP and LBI in a dance population, further investigation is required.

There was mixed information describing sex as a risk factor. Previously, it has been suggested that male dancers may be more vulnerable to LBP and LBI, due, in part, to the lifting demands required of men in ballet.[3] While this still may be the case, both males and females from ballet and contemporary dance are exposed to a variety of physical factors beyond lifting that may increase risk of LBP and LBI. In addition to physical factors, biological and psychosocial factors contribute to the initiation, maintenance, and perception of pain,[14] and these factors are pertinent to both male and female dancers. Overall, the current evidence does not support that dancers are materially different, with respect to risk factors for LBP, from other athletic or broader general populations.

Recommendations

Definitions that are sensitive to the nature of LBP in dance are needed. This is not simple. Pain is a subjective experience that fluctuates within and between individuals.[48,64] It need not be associated with identifiable tissue damage to be valid,[10,34,51] and, although the impact can be severe, many dancers who experience pain are able to maintain their ability to perform.[38] Given this, the injury definition endorsed by the International Association for Dance Medicine and Science, which considers injury as an anatomic tissue-level impairment, as diagnosed by a health care practitioner, that results in full time loss from activity for 1 or more days beyond the day of onset,[46] may not be best suited for determining the prevalence of LBP. However, an initial intent of the measurement of the International Association for Dance Medicine and Science definition was to encourage the standardization of measurement of risk factors and injury reporting,[46] which the current review endorses. To achieve this in LBP epidemiology, Dionne et al[18] proposed a minimal definition ("In the past 4 weeks, have you had pain in your low back?") that should be combined with a minimum severity criterion. Where possible, a description or diagram of the lower back area should accompany this definition.[18] In sports medicine, the Oslo Sports Trauma Research Center questionnaire has been identified as a sensitive and valid tool capable of documenting patterns of injury in athletic populations,[15] and has also been proposed as a suitable tool for dance epidemiology.[41]

Because a key function of surveillance is to assess the effectiveness of an intervention,[80] outcomes specific to the site of pain and injury are needed. For the lower back, prevalence, which refers to the proportion of the population with the condition at a given time,[60] should be used.[6] Due, in part, to high childhood and adolescent prevalence of LBP,[13] as well as the recurrent nature of LBP and LBI,[49,73] the incidence of first-time episodes of LBP

is difficult to determine. Furthermore, the percentage of all injuries located in the lower back area may be influenced by the total number of other injuries in a cohort, as well as by multiple injuries in a single dancer at the same site, suggesting that this outcome may have less value for assessing outcomes of site-specific interventions.

Multisite studies, potentially with control groups, are needed. Single-site studies may be more sensitive to site-specific effects (eg, repertoire, touring, injury reporting cultures, etc). In addition, as dance cohorts are composed of highly specialized populations, they are limited in numbers of potential participants. Multisite studies are more likely to recruit enough participants to facilitate multivariable analysis, allowing more valid conclusions. Furthermore, as LBP symptoms are prevalent in non–dance populations,[13,36] the inclusion of control groups in future studies will allow researchers to determine the proportion of LBP symptoms observed that can be attributed to dance participation.

Limitations

To limit the focus and clarity of the present review, studies that reported results that were not specific to the lower back or lumbar spine and studies that used general language to describe the site of injury were not included. As such, some studies investigating back pain or injury in dancers were not eligible for inclusion.[50] Furthermore, inclusion criteria were limited to peer review. Although this is a strength of the study, several national reports were subsequently excluded (eg, Safe Dance reports I-IV).[17,31,32,81] It is also possible that relevant studies were not included due to the search terminology employed.

No minimum sample size was set as an inclusion criterion in this study. This was due to the aim of the study, which was to synthesize all available evidence for LBP and LBI in dance, and the fact that many medium-sized dance companies consist of few permanently employed dancers. However, the utility of determining prevalence from studies with small samples should be considered when interpreting findings from specific studies. Finally, due to the range of definitions used, a meta-analysis of reported data was not possible.

CONCLUSION

Low back pain and injury are common in dance and reflect levels reported in other athletic populations. Available evidence is unable to determine whether the experience of LBP in dance is distinct from that of nondancers, or which LBP risk factors, if any, are of increased importance in a dance population. Multisite prospective cohort studies that employ definitions suitable to capture LBP and LBI, with outcomes clearly reported, would enable improved comparison with non–dance populations. Such studies would also facilitate improved identification of risk factors to better identify dancers who may need injury prevention or pain management strategies, inform dance-appropriate clinical management, and allow for monitoring of low back–specific interventions within dance. ◉

KEY POINTS

FINDINGS: Dancers are at least as vulnerable to low back pain and injury as other athletic populations.

IMPLICATIONS: Strategies are needed to improve prevention and management of low back pain and injury in dance.

CAUTION: Traditional definitions of injury underrepresent the problem, as they only partially capture the impact of low back pain.

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APPENDIX

RISK-OF-BIAS ASSESSMENT

Item	Level/Example
1. Was the study's target population a close representation of the national population?	Low risk: the study's target population was a close representation of the national population The study sampled multiple cohorts in multiple locations High risk: the study's target population was clearly not representative of the national population The study sampled a single cohort only or multiple cohorts limited to a single city
2. Was the sampling frame a true or close representation of the target population?	Low risk: the sampling frame was a true or close representation of the target population The target population was professional ballet dancers and the sampling frame was a professional ballet company High risk: the sampling frame was not a true or close representation of the target population The sampling frame was limited to only injured dancers
3. Was some form of random selection used to select the sample, or was a census undertaken?	Low risk: a census was undertaken, or some form of random selection was used to select the sample An entire cohort was invited to participate High risk: a census was not undertaken; random selection was not used Only dancers treated by 1 health professional were sampled
4. Was the likelihood of nonresponse bias minimal?	Low risk: the response rate for the study was 75% or greater or there were no significant differences in relevant demographic characteristics between responders and nonresponders High risk: the response rate was less than 75%, and there were significant demographic differences between responders and nonresponders, or differences between responders and nonresponders were not reported
5. Were data collected directly from the subjects (as opposed to a proxy)?	Low risk: all data were collected directly from the subjects High risk: data were collected from a proxy Physical therapist records were used to determine prevalence or incidence
6. Was an acceptable case definition used in the study?	Low risk: an acceptable definition of pain or injury was used, and the low back region was clearly defined Low back pain was defined as pain experienced between the lower 12th rib and upper gluteal fold and was accompanied by a diagram High risk: an acceptable definition of pain or injury was not used, and/or no description of the low back was provided No threshold for injury reporting was provided and no description of the low back region was provided
7. Was the study instrument that measured the parameter of interest shown to have reliability and validity?	Low risk: the instrument used had been shown to have reliability and validity High risk: reliability or validity had not been established
8. Was the same mode of data collection used for all subjects?	Low risk: the same mode of data collection was used for all subjects High risk: the same mode of data collection was not used for all subjects
9. Was the length of the shortest prevalence period for the parameter of interest appropriate?	Low risk: the shortest prevalence period for the parameter of interest was appropriate The study reports point prevalence, 1-month prevalence, or injury was registered upon occurrence High risk: the shortest prevalence period for the parameter of interest was not appropriate The study reports prevalence greater than 1-month recall
10. Were the numerators and denominators accurate and appropriate?	Low risk: there were no errors in the reporting of the numerator and denominator for the parameters of interest High risk: there were clear errors in the numerator and the denominator reported

Adapted from Hoy et al.[37]