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Low back pain and injury in ballet, modern, and hip-hop dancers: a systematic literature review

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Abstract

Background: Anecdotally, low back pain is a common complaint for many dancers; a comparison across recent research is needed to support or disprove this theory across genres.

Purpose: To determine the prevalence of low back pain and low back injury in ballet, modern, and hip-hop dancers through a systematic literature review. A secondary goal was to identify trends amongst dance genres, level of mastery, gender, and age, if possible.

Study Design: Literature review.

Methods: PRISMA search strategy terms between November 2017 and March 2018 with an ADA grading evaluation and a modified Newcastle-Ottawa Risk of Bias assessment. Twenty-five ballet articles, 5 modern, and 3 hip-hop met the inclusion criteria.

Results: Prevalence of low back pain or injury seems relatively high in ballet dance; little research exists on the prevalence of back pain in hip-hop or modern dancers. Twenty-five of the 33 studies relied on a questionnaire to gather their data.

Conclusion: Ballet dancers are at risk for low back pain or injury independent of gender, age or level of mastery; there is not enough evidence to draw any conclusions about modern dancers or hip-hop dancers and their relationship to low back pain/injury currently. Future studies need a higher level of evidence and a reduced risk of bias.

What is known about the subject: There are several injury studies on ballet dancers, but they report 'low back pain' or 'injury' as a footnote to other injuries. Few studies use modern and hip-hop dancers as participants. The research on ballet dancers fluctuates wildly in reported prevalence, and differing reporting methods prevent direct comparison.

What this study adds to existing knowledge: This study illuminates the dearth of research, especially those of high-quality and non-ballet participants. This study aims to call attention to this gap and promote vigorous scholarship for related research moving forward.

Key Words:

Lumbar pain; Professional dance; Sports injury

Introduction:

If a dancer's body is inhibited by injury, they cannot fulfill their potential as a dancer. Chronic injuries can endanger a dancer's ability to dance for the rest of their lives. In the last 30 years, most professions have moved towards a trend of incomplete retirement.¹ This is particularly true for dancers, where much of a dancer's identity is tied to their ability to stay connected to dance throughout their life, and injuries can threaten this identity.² Many dancers continue in other aspects of the dance industry once they retire from professional performing, and with a retirement age in their late 20's/early 30's,³ this is similar to sport, and significantly earlier than national mandatory retirement ages.⁴ Keeping dancers injury-free throughout their career and during their partial retirement is central to supporting dancers.

Low back pain (LBP) is a significant problem worldwide,⁵ with prevalence in the general population suggested to have a one-month prevalence of 23.2+/-2.9%⁵ and a general prevalence to be 9.4% in 2010 and on the rise.^{4,6} Data suggest that dancers show an increased prevalence of LBP in comparison to those in the general population,⁷ who exercise less often. Much of existing literature on low back pain and injury does not subdivide their study population by genre of dance, often using the umbrella term 'dancers' or combination labels like 'modern and ballet dancers'. These terms do not give context to the main dance genres studied and prevents comparisons. Current literature also prioritizes female professional ballet dancers as the subjects of study, with few studies on modern and hip-hop dance. The movement demands of these three dance genres are not the same, with several researchers noting differences between ballet and modern dance.⁸ Thus, it cannot be assumed that the prevalence of low back pain or injury in one dance genre is identical for all dance genres.

Dance has a high rate of injury,⁹⁻¹⁸ particularly amongst professional ballet dancers.¹⁹⁻²¹ This injury rate has been linked to short professional careers that often end before the dancer reaches 40 years of age,^{22,23} although the field of dancer retirement has been under-researched.²⁴ Lower extremity injuries are the most common injuries, followed by neck/trunk/spine injuries.^{10,14-17,20} It is difficult to assess mean incidence rates across multiple studies, but LBP in dancers is an ongoing injury that has been documented to have a lasting negative effect on dancers, even after they have stopped dancing professionally.²⁵ Dancers of all ages, sex, proficiency levels, and genres experience low back pain and injury. A number of literature reviews, particularly those that center on ballet dancers, have cited LBP anywhere from 3%-23%¹⁵ to 12%-75%¹⁶ prevalence, or a calculated prevalence of 14%.²⁰

Since data collection ended in March 2018, more promising research has surfaced in the form of systematic reviews²⁶ and interventions,²⁷ but there is still not enough standardization in the field. Studies on LBP do not always agree on a standard definition of what LBP is, and this is also true for LBP research on dancers. MeSH database defines "low back pain" as, "Acute or chronic pain in the lumbar or sacral regions (MeSH Unique ID: D019567)."²⁸ The MeSH database does not have a definition for low back injury (LBI), but defines "back injury" as, "General or unspecified injuries to the posterior part of the trunk. It includes injuries to the muscles of the back (MeSH Unique ID: D017116)."²⁸ A modified Delphi study published in 2008 suggests that questionnaires that address LBP should ask for a recall of no more than 4 weeks, to clarify with subjects whether this low back pain limited or changed daily activities for more than one day, and to include an anatomical diagram that highlights the low back.²⁹

Dancers' performance will be inhibited by LBP or LBI; more research into which dancers are at risk for developing LBP or LBI will assist these efforts, validating the need for more studies that focus on determining gaps in the LBP and LBI dance literature. Understanding the prevalence of LBP and LBI in individual dance genres warns dance trainers if their specific population is at risk, particularly if there are additional trends of risk amongst skill level, gender, or age. Preventative trainings and interventions can then be established with an aim towards decreasing the prevalence and, as a result, increasing dancer quality of life and longevity. Therefore, the primary objective of this study was to determine prevalence

of low back pain or injury in ballet, modern, and hip-hop dancers. The secondary objective was to identify whether there are trends in the data for dance genre, level of mastery, gender and age, if possible.

Methods:

Search Methodology:

This review was conducted between November 2017 and March 2018 using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. A search was conducted of titles and abstracts in Pubmed (1966 to March 2018), MEDLINE (1946 to March 2018), SPORTDiscus (1983 to March 2018), Web of Science (1900 to March 2018), Journal of Dance Medicine & Science online archives (1997 to March 2018) databases using six permutations of the MeSH keyword “back pain” or “injury” and text words, as shown in Table 1.

Table 1: Search Methodology Keywords and Fields Used to Locate Articles

In title:	All fields, MeSH terms:
dancers	"back pain"
dancers	back pain
dancers	lumbar pain
dance	back pain
	dancers lumbar injury
	dancers “back injury”

Please note that both ‘injury’ and the plural term ‘injuries’ was included automatically by the search engines, or manually searched when not automatically included by the databases’ search engines.

We conducted a hand search of the reference lists of identified studies. A single investigator conducted the search actions and initial screening processes. Three articles that did not have an accompanying English translation were assessed with the help of translation applications: two in Portuguese^{30,31} and one in German.³²

Inclusion criteria were:

- having addressed low back pain or injury in a ballet, modern, or hip-hop dance population.
- The “Ballet” genre included sub-genres classical, contemporary, and neo-classical ballet dance.
- “Modern” dance included sub-genres related to both classical modern (i.e. Graham technique) and newer post-modern.
- “Hip-hop” incorporated studies on its subgenres, most notably breaking, locking, and popping.

Exclusion criteria were

- participants from dance genres other than ballet, modern, or hip-hop dancers,
- participants were not specified or separated by dance genre,
- not testing for back pain or injury (performance measures alone were not satisfactory),
- examining back pain as related to a specific pathology,

- duplicated data published in different publications,
- case studies or series,
- non-primary sources (i.e., literature reviews),
- grouping the lumbar spine with other areas of the body,
- articles without English translated titles (those articles with titles translated to English were included, even if the article itself required some translation).

Initial Screening:

Our electronic database search yielded 639 articles, combined with 41 additional records identified through other sources, such as references lists, to produce 680 total articles. Two hundred and eighty remained after duplicates were removed, excluding 290 of the remaining articles for not meeting inclusion criteria (Figure 1). We addressed differences in the categorization of “genre name” by the inclusion of sub-genres; for example, Graham or Horton were classified as modern, and Breakers, Poppers/Lockers, or New Schoolers were categorized as hip-hop. In contrast, studies that used the umbrella term “dance”, instead of specifying a main discipline or exposure hours, were excluded.

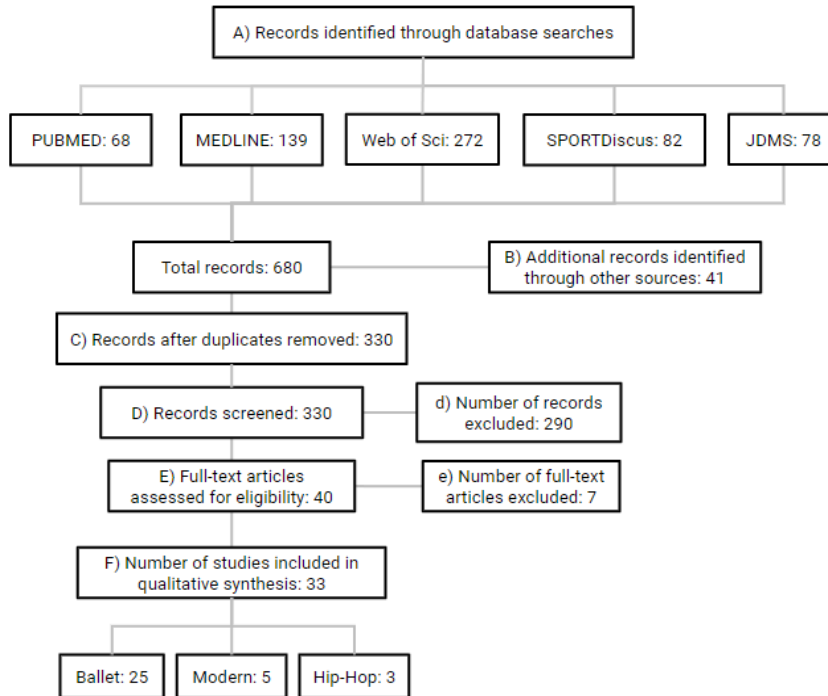


Figure 1: PRISMA Flow Diagram Detailing the Article Search Strategy in studies examining Low Back Pain and Injury in Dancers

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Full-Text Assessment Procedure:

After the initial screening of titles and abstracts, two researchers independently performed a full-text assessment of the remaining 40 articles, leading to the exclusion of 7 more articles. We assessed studies for their quality based on the ADA Research Committee’s 2013 adaptation³³ of Greer *et al.*’s original evidence grading strategies,³⁴ referred to ‘ADA scoring system’ for the remainder of this article. There were five grades given to the articles once examined: Good I, Fair II, Limited III, Expert Opinion Only IV, Grade Not Assignable V. To assess these good quality studies in detail, we used a data-extraction sheet for the full-text assessment, the results of which we compiled into a spreadsheet and then processed. A third researcher acted as a third reviewer for any disputed scores. We measured Risk of Bias using a modified Newcastle-Ottawa assessment.³⁵

Results:

Included Studies:

The final count of eligible articles rendered 25 ballet articles,^{11,13,21,25,30-32,36-53} five modern,⁵⁴⁻⁵⁸ and three hip-hop.⁵⁹⁻⁶¹ Sixteen articles studied at least one population of current professional ballet dancers. The incidence of LBP and LBI varied extensively, even between the scarce modern and hip-hop results. The results of this study can be found in Tables 2, 3, and 4 for ballet, modern, and hip-hop data, respectively.

Study Design and Risk of Bias

Twenty-five^{21,25,30-32,36-40,44-49,51-52,55-61} of the 33 studies collected self-reported data via questionnaire. Thirteen^{11,13,32,41-45,49-50,53-55} studies included the use of medical records and six^{31,13,38-39,49,61} used physical screenings to determine incidence of pain or injury to the low back. Thirteen studies^{13,31,32,38-40,44-47,49,55,61} utilized multiple data collection methods. Few studies measured back pain identically, although most used a modified retrospective survey across a set amount of time (i.e., “Have you had back pain within the last week? Month? Year?”). The injury definitions of “low back pain” or “low back injury” varied, with studies describing pain as “mechanical low back pain”,^{31,42} or defining injuries to this area as “lumbar lesions”.³⁶ Studies that examined the duration of pain over the course of a dancer’s career used the terminology “lifetime history of low back pain”²² or “lifetime prevalence of low back pain”.⁶²

Table 5: Risk of Bias Reporting Summary (modified Newcastle-Ottawa Method) in Articles examining Low Back Pain and Injury in Dancers

Stars (out of 10)	Number of studies
7	9
6	9
5	10
4	4
3	1

A summary of the results of the Risk of Bias assessment can be found in Table 5. We used an adapted Newcastle-Ottawa method³⁵ specific to cross-sectional studies, which grades each study out of

Table 2: Summary of Articles examining Low Back Pain and Injury in Ballet Dancers

Article Title	First Author & Year	Design	Collection Methods / Intervention	Level of Evidence	Sample size, mean age/range	Terms used	Level of Mastery & Avg Amt of Dance	Relevant Outcomes: Total with LBP/I	Males with LBP/I	Females with LBP/I	Notes & Limitations	Data Reported As	GRADE score
1 Characteristics and prevalence of musculoskeletal injury in professional and non-professional ballet dancers	Costa <i>et al.</i> 2016	Retrospective case-control study	Questionnaire; prof vs non-prof dancers to assess presence, location, and mechanisms of injury Non-random sampling; convenience sample	3	n = 110 (88 F), 17.6+/-9.3 yrs avg	"lumbar lesions"	Professional; 5.8+/-1.0 hrs/day	12/53, 22.6% Professional women seemed the most affected by injury	10/22, 45.5%	2/31, 6.5%	All 110 completely answered questionnaires were included. Relied on dancer memory. Most injuries occurred in relation to jumps; suggest 'taking into consideration the dancers' movements.'	people with injury	Fair II
							Student/Pre-P; 2.6+/-1.7 hrs/day	3/57, 5.3% This study observed a low frequency of LBP, contrasting other studies	-	-			
2 National survey to evaluate musculoskeletal health in retired professional ballet dancers in the United Kingdom.	Smith <i>et al.</i> , 2017	Retrospective cross-sectional study	Questionnaire; online national survey of retired prof ballet dancers in the UK for current MS issues & location, and cause of retirement Non-random sampling; snowball sample	3	n = 46 (14 F but not all reported), 50 yrs IQR 42-56	"Low back [muscle and joint pain]"	Retired Professional; no activity level given	32/46, 71% Retired dancers said were most affected by muscle and joint pain. Retired dancers seem to still be experiencing pain post-dancing professionally	-	-	Not all data reported/completed, bias of non-reporting. These are retired professionals, so training and activity level may have varied since they were dancing. Relied on dancer memory. Low response rate.	people with pain	Fair II
3 Musculoskeletal injuries in young ballet dancer	Leanderson <i>et al.</i> , 2011	Retrospective, open cohort study;	Medical records; assessed records Aug 1988-June 1995 for diagnosis, location, and type of injuries Non-random sampling; convenience sample	2	n = 476 (297 F), 10-21 yrs	"low back pain"	Student; 6hr/wk in 4th grade, 10.5 hr/wk in 5th/7th grades, 15 hr/wk in 9th,10th, and 11th grades	45/476, 9.5% recorded injury records as they happened, but this study takes place in 2006-7, when they went back and assessed the records. They suggest that injury incidence increases with age	22/179, 5.1%	23/297, 5.3%	No exclusion criteria applied. Records were a bit old at the time of assessment, but they defend that the dance training has "most likely not changed significantly"	# of pains	Fair II

4	Injury patterns in elite preprofessional ballet dancers and the utility of screening programs to identify risk characteristics.	Gamboa <i>et al.</i> , 2008	Retrospective descriptive cohort study	Screenings, Medical records; took place over 5 years; screened at the beginning, and injury data collected at the end of each year Non-random sampling: convenience sample	Prognosis, level 2b	n = 359 (288 F), 14.7+/- 1.9yrs avg, 9-20 yrs	"history of low back pain"	Pre-Professional; ~20 hrs/week of ballet (ten 1.5 hr classes, three 1 hr rehearsals, one 2-hour rehearsal; 2 hours cross training and Pilates mat per wk)	injured: 73, 44% non-injured: 125, 27% Retro review of physical therapy records at the end of the school year; compared injured and non-injured groups.	-	-	A broad-based screening program did not identify robust physical factors predictive of injuries in elite pre-professional adolescent dancers. The rate of injuries in dancers may be best understood when measured as number of injuries per 1000 hours of dance.'	people with pain	Good I
5	Verletzungen und Überlastungserscheinungen im professionellen Ballett	Arendt <i>et al.</i> , 2003	Retrospective cohort study	Questionnaire, Medical Records; A personal survey with training attention, a problem-oriented clinical-orthopedic examination and, if available, a review of the medical documents; compared subjective complaints to medically treated injuries Non-random sampling: convenience sample	3	n = 77 (42 F), 20-34 yrs	"lumbar spine"	Professional; 45-50 hrs/wk for most dancers; does give data for above and below this range	499/567, 88% 'common discomfort described in the lumbar spine' out of the 285 F injuries and 282 M injuries over a 5-year period	-	-	They suggest a link between 'anatomical and technical deficiencies' and LBP	# of injuries	Fair II
6	The prevalence and impact of low back pain in pre-professional and professional dancers: A prospective study.	Swain <i>et al.</i> , 2018	Prospective Cohort Study	Questionnaire; initial questionnaire for LBP history, then monthly prevalence of LBP & impact was collected over 9 months Non-random sampling: convenience sample	2	n = 168 (100 F), 11-25 yrs pre-p: n = 95, 11-18 prof: n = 29, age range unavailable student: n = 77 & n = 19, 17-25	"any LBP", "activity limiting LBP", and "chronic LBP" ; "History of LBP"	Student, Pre-Professional, Professional; mean dance hours/month ranged between 49.9 and 85.3 (SD range: 21.4 to 44.4).	93/119, 78% 62/119 52% 29/119 24% Table 1 gives their descriptive data: 93 had 'any LBP', 62 had 'activity limiting LBP', and 29 had 'chronic LBP'	15/19, 79% 15 M had history of LBP, but data was missing for 11 cases	65/100, 74% 65 F had history of LBP, but data was missing for 11 cases	No significant relationship was also identified between monthly dance hours and the monthly prevalence of any LBP or AL LBP' 'The current study was unable to find any overall association between the experience of LBP and the participation data collected'	people with pain	Fair II

7	Analysis of the relationship between low back pain and muscle strength imbalance in ballet dancers	de Aquino <i>et al.</i> , 2010	Cross-sectional cohort study	Questionnaire & Screenings; questionnaire to divide into Pain and No Pain groups, and then submitted to test battery Non-random sampling: convenience sample	3	n = 42 (42 F), 16.4yrs avg, 13-25 yrs	"mechanical lumbar pain"	Pre-Professional; 3.9 +/- 1.5 hrs/wk	21/42, 50% 'For the Pain group, the dancers should present chronic low back pain (reports of symptoms recurrent for more than 12 weeks) and of mechanical origin.' of which there were 21	-	21/42, 50%	The main movement that aggravated the low back pain in the dancers of the Pain group were the hyperextension of the trunk (85.7%) and the more frequent relief movement was the anterior flexion of the trunk (57.1%). 'there were also imbalances in ABD x FQ that associated significantly with LBP	people with pain	Fair II
8	Validation of a Pain Questionnaire (SEFIP) for dancers with a specially created test battery	Ramel <i>et al.</i> , 1999	Cross-sectional study	Questionnaire & Screenings; did a survey, then did a test battery, and compared the two Non-random sampling: volunteer sample	3	n = 28 (17 F), 27.6 yrs avg, 19-43 yrs	"low back pain"	Professional; no activity level given	17/28, 60.7% Both the test battery and their SEFIP exam found 17 dancers with LBP, but it was not the same 17 dancers (one dancer reported pain when the TB found none, and vice versa)	-	-	Did not give data for amount of dancing per week 'Overall, the SEFIP questionnaire shows good agreement with the actual pain found on physical examination.'	people with pain	Fair II
9	Life history and point prevalence of low back pain in pre-professional and professional dancers.	Swain <i>et al.</i> , 2017	Cross-sectional study.	Questionnaire; measured lifetime and point prevalence of LBP Non-random sampling: convenience sample	3	n = 110 (91 F), 17.8 yrs avg (17.9 F & 17.1 M)	"lifetime history of low back pain:	Student, Pre-Professional, Professional; 13-18.5 hrs/wk for students, 24 hrs/wk for Pre-P, Prof activity level not given	81/110, 74% 'A 74% lifetime prevalence of LBP was reported by dancers. Point and 12-month prevalence were 24 and 64%, respectively.'	15/19, 78.9%	66/91, 72.5%	No significant association was observed between LBP and any demographic or physical variables.'	people with pain	Limited III
10	Trunk Dynamics Are Impaired in Ballet Dancers with Back Pain but Improve with Imagery	Gildea <i>et al.</i> , 2015	Non-RCT, cohort study.	Interview; split into those with and without LBP, then Questionnaires, then dampening was measured in both groups, and then again after using imagery to see if the dampening improved Non-random sampling: volunteer sample	2	n = 30 (19 F), 24.4 yrs	"low back pain"	Professional; "on full workloads", no activity level given	22/30, 73% 'Of the 30 dancers, 22 dancers reported pain in the lower back or pelvic/hip region.' 14 reported LBP within the preceding 6 months, and 8 reported pain before that (0.5-13 yrs)	-	-	Made assumptions about simplification of the trunk muscles in order to enable estimation of trunk parameters. Convenience sampling limited the size of pain-free group 'Trunk damping, but not stiffness, is modified in dancers with a history of LBP.' & 'Dancers with a history of LBP can use imagery to modify trunk mechanical properties.'	people with pain	Good I

11	Morphology of the abdominal muscles in ballet dancers with and without low back pain: A magnetic resonance imaging study.	Gildea <i>et al.</i> , 2014	Observational study	Questionnaire; separated into LBP and no LBP groups, then assessed via MRI for thickness of TA and OI ab muscles Non-random sampling: volunteer sample	3	n = 31 (17 F), F: 23.3 yrs avg M 24.4 yrs avg	"pain in the region of the lower back"	Professional; in the Int'l Phys Act Questionnaire, all dancers scored 'high' physical activity category	23/31, 74% Three groups for comparison post-questionnaire; no history of hip region or LBP (n = 8); history of / or current LBP (n = 13); history of / or current hip region and LBP (n = 10) ...thus 23 with LBP (regardless of hip pain).	-	-	The preliminary evidence of compromised behavior of TrA muscles in LBP provides a foundation... to move forward with more research. 'Participants with LBP also completed a Roland-Morris Disability questionnaire and Oswestry Disability questionnaire. Except for pain, there was no difference in demographic data among groups (ANOVA).'	people with pain	Fair II
12	Recurrent musculoskeletal pain in professional ballet dancers in Sweden: a six-year follow-up	Ramel <i>et al.</i> , 1999	Cohort study	Questionnaire; Nordic Musculoskeletal Questionnaire to assess pain was administered in the middle of the fall season in 1989 and the middle of the spring season in 1995 Non-random sampling: convenience sample	3	n = 51 (34 F) 1989: 26 (22-31) 1995: 32 (28-37)	"pain...reported in the low back"	Professional (1989) Individual demand based on median hrs of work: High 7, Medium 15, Low 18, No answer 11	last 12 mos: 69% last 7 days: 26% incapacitating last 12 mos: 28% (1 missing answer)	-	-	Missing responses from their questionnaire. 'Highly selected group' so less generalizability. 'In spite of an increased 12-month pain prevalence over the years, the incapacitating pain for the persons in this study did not increase. These dancers somehow lived and worked with their pain, in spite of an increased number of performances over the years.'	people with pain	Limited III
								Professional (1995) Individual demand based on median hrs of work: High 7, Medium 15, Low 18, No answer 11	last 12 mos: 82% last 7 days: 37% incapacitating last 12 mos: 33%	-	-			
13	Injuries in a Professional Ballet Dance Company A 10-Year retrospective study	Ramkumar <i>et al.</i> , 2016	10-year retrospective study	Medical records; Data regarding the dancers' age, gender, location of injury, and diagnosis were collected from workers' compensation claims, company records, and medical records maintained by the treating doctors. Non-random sampling: convenience sample	3	n = 153 (81 F), 27.5 yrs	"lumbar strain...injury"	Professional; 27.5 hrs/wk excluding performance and dress	117/574, 20% frequency of lumbar spine injury ~20%; most common diagnoses in prof ballet were lumbar strain ~20%...lumbar spine strain was 117 out of 574 total injuries	-	-	Disproportionate occurrence of injuries over a season was not accounted for. Could not distinguish overuse vs. traumatic (except fractures). 'The data reveal that a dancer experiences at least one new injury every year.'	# of injuries	Good I

14	Overuse Injuries in professional ballet: injury-based differences among ballet disciplines	Sobrino <i>et al.</i> , 2015	Cross-sectional study	Medical records; Data, including type of injury, were obtained from specialized medical services at the Trauma Service, Fremap, Madrid, Spain. Attempt at random sampling	3	n = 145 (? F), 25.79 +/-5.69 yrs	"mechanical low back pain" & "lumbar muscle injury"	Professional; no activity level given	3/76, 3.95% 486 injuries were evaluated, 366 total overuse injuries, with 82.6% of the total injuries for classical ballet being overuse as opposed to traumatic/other. In total there were 76 classical ballet injuries (25 M 51 F) and 3 of these were Mechanical low back pain 3.95% (0 M, 3 F) Also, 1 (1M, 0 F) had Lumbar muscle injury out of the 76 injuries	0/25, 0% 1/25, 1.32%	3/51, 5.88% 0/51, 0%	Did not give activity level. Prevalence of overuse injuries...in classical ballet and among women.	# of pains	Good I
15	The effect of spinal and pelvic posture and mobility on back pain in young dancers and non-dancers	McMeeken <i>et al.</i> , 2002	Cross-sectional study	Questionnaire; dancers vs non-dancers received a questionnaire concerning the type and amount of regular activity and history of LBP; then did videotape motion analysis of trunk posture and movement Non-random sampling: volunteer sample	3	n = 120 (82 F) (41 dancers (? F)), 17.2 +/-3.6 yrs	"low back pain episodes in the last year"	Student, Pre-Professional; at least 6 hrs per week; non-dancers: one did 5 hrs/wk and nine did less than 3 hrs/wk	15/41, 36.6% Visual analogue scales used for intensity. Their Table 6 shows that 15 dancers had pain episodes in the last year, and that the pain lasted avg 14 days with max intensity 66.6+/-23.9 / 100	-	-	They did not separate dancers by gender. 'no links between low back pain and sagittal pelvic tilt and lumbar postures. ...Our study did not demonstrate that greater spinal mobility was a useful predictor of the risk of back pain in dancers.'	# of pains	Fair II
16	A prevalência de dor em bailarinas clássicas The prevalence of pain in classical ballet dancers	Batista <i>et al.</i> , 2010	Retrospective cross-sectional study	Questionnaire; "EVA" visual analogue scale questionnaire gathered data on location of pain for pointe dancers in Cubatão Non-random sampling: convenience sample	3	n = 30 (30 F), 20.4 +/-4.5 yrs	"dor da regioo lombar"	Student; 18.7 hrs/wk	12/30, 20.30% They also looked at intensity of pain via EVA	-	12/30, 20.30%	It is important to emphasize that the modalities jazz and modern dance were not considered as other types of activities because they are part of the curriculum of the school where the research was carried out	people with pain	Limited III
17	Ballet Injuries: Injury Incidence and Severity Over 1 Year	Allen <i>et al.</i> , 2012	Prospective, descriptive single-cohort study.	Medical records; in-house medical team recorded time-loss injuries Non-random sampling: convenience sample	2	n = 52 (27 F), F: 25+/-6 yrs M: 23+/-5 yrs	"lumbar pain undiagnosed, lumbar muscle spasm/strain/tear"	Professional; 31.5 - 35.5 hrs/wk	30/355, 8.5% FEMALES: lumbar muscle spasm/strain/tear 11 instances, lumbar pain undiagnosed 3 instances of 172 total injuries MALES: lumbar muscle spasm/strain/tear 13 instances, lumbar pain undiagnosed 3 instances of 183 total injuries	16/183, 9%	14/172, 8%	Reliability and validity of the injury surveillance tool were not established.' 'Prof ballet dancers have a high proportion of ...lumbar spine and overuse injuries. Gender differences in injury incidence and profile were identified.'	# of pains	Good I

18	Musculoskeletal injuries in the Norwegian National Ballet: a prospective cohort study	Byhring <i>et al.</i> , 2002	Prospective cohort study	Questionnaire, Medical records; history questionnaire, and then 19-week prospective study of injuries as registered by medical staff. Non-random sampling: convenience sample	2	n = 41 (27 F), 26.7 yrs 19-40 yrs	"low back"	Professional; 30-40 hrs/wk	1/10 time away from work injuries, versus about 8 out of the 64 total injuries. Fig. 1 does show complaints of the low back, but only graphically, so it is difficult to assess the exact number of injuries (8 low back?). Later, they explain out the 64 injuries, 10 resulted in time off, and one of those ten was a low back injury	-	-	The study sample did not differ from the whole population regarding gender, age, and professional status' & 'it is concluded that there is a high incidence of MS injuries in the Nor Nat'l Ballet'	# of injuries	Fair II
19	The injury panorama in a Swedish professional ballet company	Nilsson <i>et al.</i> , 2001	Combined retro- and prospective study	Questionnaire, Medical records; injuries were recorded through medical professionals over 5 consecutive years and a retrospective recording of the first two years was made through a form that was designed to register the diagnosis, site of injury, injury mechanism, and type of injury. Non-random sampling, but they did follow the company over five years, making it more representative than most convenience samples	2; 3	n = 98 (50 F), 26.6 yrs 17-47 yrs, 390 injuries	"lower back, gluteal region...overuse"	Professional; 48 hrs/wk	70/390, 17.9% Study showed T/O: proportion of these injuries that were traumatic versus overuse. Only the overuse data were used.	35/182, 19.2%	35/208, 16.8%	The injury patterns in the retrospective and prospective parts of the study were similar. Furthermore, the present study demonstrates a difference in injury pattern between male and female dancers.'	# of injuries	Fair II
20	Ballet dancer's turnout and its relationship to self-reported injury.	Coplan 2002	Retrospective cohort study.	Questionnaire, Screenings; divided into LBP or no LBP, then measure first position turnout and passive ext rotation ROM Non-random sampling: convenience sample	2	n = 30 (27 F), 16-50 yrs	"low back injury"	Student; no activity level given	3/22, 13.6% Twenty-two total injuries of the following kind were reported: knee (n = 8 or 36%), shin (n = 5 or 22.7%), low back (n = 3 or 13.6%), ankle (n = 3 or 13.6%), hip (n = 1 or 4.5%), and foot (n = 1 or 4.5%).	-	-	Compensated turnout was greater in injured groups. No data were collected describing the hours of practice or level of experience and performance of the subjects. A lack of formal diagnosis of injury and the limited number of subjects. The survey relied on the self-reported history of injury and therefore the memory of the dancer.	# of injuries	Fair II
21	Lumbosacral pain in ballet school students. Pilot study.	Drężewska <i>et al.</i> , 2013	Combined retro- and	Questionnaire, Medical Records, and later,	2	n = 71 (45 F), 16.5 yrs	"with lumbosacral pain"	Pre-Professional; 19.7 hrs/wk with	44/71, 62% Gender split was not	-	-	Age and Years Dancing "Dance Seniority" were	people with pain	Fair II

			prospective study	Screenings. The questionnaire established who did and did not have back pain and was corroborated by medical history forms; the VAS was used for subjective pain intensity, and they screened after that. Non-random sampling: convenience sample		avg (15-18 range)		10-30 hr/wk range	statistically significant			statistically significant; pain increased with age and seniority LBP increased as BMI was below normal		
22	Traumatic injuries in professional dance-past and present: ballet injuries in Berlin, 1994/95 and 2011/12.	Wanke <i>et al.</i> , 2014	Retrospective cohort study	Medical records; work accident reports from three theaters Non-random sampling: volunteer sample	2	n = 241 accidents (participant numbers not given), 1994/95: 28 yrs avg 2011/12: 29.5 yrs avg	"traumatic injuries to the lumbar spine"	Professional; no activity level given	1994/95: 9/155, 5.8% 2011/12: 17 or 18 out of 86, reported as 20.3%, although the nearest whole accident is either 19.8% or 20.9%	-	-	Dramatic increase in LBI from 1994/95 to 2011/12,	# of injuries	Fair II
23	Kinematics of the lumbar spine during classic ballet postures	Feipel <i>et al.</i> , 2004	Retrospective cross-sectional study	Questionnaire; self-administered of their own design Non-random sampling: convenience sample	3	n = 25 (17 F), 21 +/- 4 yrs avg	"current low-back pain"	Professional, Pre-Professional; at least 20 hrs/wk of dance	10/25, 43%	-	-	Participants who danced less than 20 hrs/wk or less than 6 years total ballet experience were excluded from their study	people with pain	Fair II
24	The association between body-built and injury occurrence in pre-professional ballet dancers - separated analysis for the injured body-locations	Zaletel <i>et al.</i> , 2017	Retrospective cross-sectional study	Questionnaire; self-administered of their own design that was verified by test-retest for reliability Non-random sampling: convenience sample	3	n = 24 (24 F), 16-18 yrs	"lumbar region injury"	Pre-Professional; 20-25 hrs/wk	8/60, 13.3% Occurred during training: 7/8, 88% Occurred during performance: 1/8, 12%	-	8/60, 13.3%	Their questionnaire asked for injuries in the last year only.	# of injuries	Fair II
25	Ballet injuries. An analysis of epidemiology and financial outcome.	Garrick <i>et al.</i> , 1993	Retrospective cohort study	Medical records; workers' compensation insurance records for 3 years of a ballet company Non-random sampling: convenience sample	2	n = 104, age not reported	"injury to lumbar region" that resulted in medical expense	Professional, Pre-Professional; no activity level given	71/309, 23.0%	-	-	Reported sparse demographic data	# of injuries	Fair II

Table 3: Summary of Articles examining Low Back Pain and Injury in Modern Dancers

Article Title	First Author & Year	Design	Collection Methods / Intervention	Level of Evidence	Sample size, mean age/range	Terms used	Level of Mastery & Avg Amt of Dance	Relevant Outcomes: Total with LBP/I	Males with BP	Females with BP	Notes & Limitations	Data Reported As	GRADE score
1 Injuries in students of three different dance techniques.	Echegoyen <i>et al.</i> , 2010	Prospective cohort study	Medical records; a sport physician recorded the data concerning injuries (at least one absence from dance class/rehearsal). Non-random sampling: convenience sample	2	n = 444 (F ?); 23.10 +/- 3.04 yrs for modern, 23.85 +/- 3.05 yrs for Mexican folkloric, and 22.5 +/- 3.04 yrs for Spanish dance.	"back pain"	Student; training 11.6-13.3 hrs/wk with 1.6 hr/wk rehearsal	54/620, 8.70%; 1168 total injuries over 3 years, 620 modern injuries.	-	-	Modern dance had 2x as many injuries as Mexican Folkloric, and ~5x as many injuries as Spanish dance...that is a little more than 1 injury for each modern dancer per 3 years.	# of pains	Good I
2 Self-reported and reported injury patterns in contemporary dance students.	Baker <i>et al.</i> , 2010	Combined retro- and prospective study	Questionnaire, Medical records; questionnaire adapted Dance UK's injury questionnaire and medical records from Injury Zone UK Sport electronic athlete medical record system) Non-random sampling: convenience sample	3; 2	n = 57 (47 F); F: 20.0 +/- 2.51 yrs M: 21.0 +/- 3.00 yrs in ~6.5 months, they took 180 hr contemporary and 144 hr ballet	"Lower back injuries"	Student, Self-Reported (324 hrs/10 months=32.4hrs/month~8 hrs/wk)	6/70, 8.6%	3/14, 21.4%	3/56, 5.4%	The resulting frequency was too low for statistical analysis for this size of research, thus they examined trends. Cautioned about generalizing for the greater population since the goal of this study was feedback to the conservatory specifically.	SELF-REPORTED; # of injury	Fair II
							Student, Reported (324 hrs/10 months=32.4hrs/month~8 hrs/wk)	9/63, 14.3%	1/11, 9.1%	8/52, 15.4%		REPORTED; # of injuries	
3 Technique as a consideration in modern dance injuries.	Solomon <i>et al.</i> , 1986	Retrospective cross-sectional study	Questionnaire; a questionnaire they created, no details given. Non-random sampling: convenience/snowball sampling	3	n = 164 (127 F); 26.15 ± 6.43 yrs avg, 16-48 yrs	"Lower back Injuries"	Graham technique (no activity level given)	38/229, 16.7%	-	-	Relies on dancer recall; snowball sampling limits generalizability. Did not separate their professional and non-professional results.	# of injuries	Fair II
						"Lower back Injuries"	Horton technique (no activity level given)	49.5/229, 21.6%	-	-			
4 Assessment of Compensated Turnout Characteristics and their Relationship to Injuries in University Level Modern Dancers	van Merkensteijn <i>et al.</i> , 2015	Retrospective cross-sectional study	Questionnaire; self-reported injury of their own making Non-random sampling: convenience sample	3	n = 22 (20 F); 21.27 +/- 1.279 yrs avg	"Low back pain"	Student; 20 hrs/wk plus time for various supplemental training	6/22, 27.3%	-	-	Asked for past 2 years of injury data, questionnaire was not verified. Concluded that all dancers compensated turnout, but to a lesser degree than previous research.	People with pain	Fair II
5 Injuries in Professional Modern Dancers: Incidence, Risk Factors, and Management	Shah <i>et al.</i> , 2012	Retrospective cross-sectional study	Questionnaire; large scale survey, with a previous publication detailing the design (Weiss, 2008) Attempt at obtaining full sample size, but response rate and underrepresentation of free-lance modern dancers inhibits representativeness	3	n 184 (173 F); 18-55 yrs, 30.1 +/- 7.3 yrs avg	"Low back injury"	Professional; 8.3 +/- 6 hrs/wk in class, 17.2 +/- 12.6 hrs/wk in rehearsal, 8.2 +/- 6.6 hrs/wk various supplemental training	40/230, 17%	-	-	Injury data was from preceding 12 months. High incidence of injury overall (82%) but does rely on self-reporting and recall of participants.	# of injuries	Good I

Table 4: Summary of Articles examining Low Back Pain and Injury in Hip-Hop Dancers

Article Title	First Author & Year	Design	Collection Methods / Intervention	Level of Evidence	Sample size, mean age/range	Terms used	Level of Mastery & Avg Amt of Dance	Relevant Outcomes: Total with LBP/I	Males with BP	Females with BP	Notes & Limitations	Data Reported As	GRADE score
1 Pain Prevalence Among Female Street Dancers	Grčić <i>et al.</i> , 2017	Retrospective cross-sectional study	Questionnaire; used a basic health and data questionnaire and the SEFIP Non-random sampling: volunteer sampling	3	n = 137 (137 F); 19.7 yrs avg	"Lower back"	Novice 3-6 hrs/wk	34/73; 46.6%	-	34/73; 46.6%	LBP was the most common issue. Street dancers do not have the same supervision, so this may make them more injured. Relied on dancer recall.	people with pain	Fair II
							Student 7-10 hrs/wk	19/34, 55.9%	-	19/34, 55.9%			
							Pre-Professional 11-15 hrs/wk	9/16, 56.2%	-	9/16, 56.2%			
							Professional 15+hr/wk	12/14, 85.7%	-	12/14, 85.7%			
2 Injury incidence in hip hop dance	Ojofeitimi <i>et al.</i> , 2010	Retrospective cross-sectional study	Questionnaire; A Web-based survey was conducted over a 6-month period. attempted Random Sampling	3	n = 232 (169 F); range 13-44 yrs F: 24.7 +/- 5.5 yrs avg M: 23.4 +/- 5.4 yrs avg	"Trunk: Lumbar/Pelvis...Injury"	"Student, Teacher, Professional"; activity level not provided	Physical Complaint 50/738 (7%)	-	-	This study did give the years of dancing but did not give current activity level. Does break down results by sub-genre: Breakers, Poppers/Lockers, Newschoolers	PHYSICAL COMPLAINT, # of injuries TIME LOSS, # of injuries	Fair II
								Time Loss 38/506 (8%)	-	-			
3 Musculoskeletal injuries in break-dancers	Cho <i>et al.</i> , 2009	Combined retro- and prospective cross-sectional study	Questionnaire, Screenings; questionnaire was for the basics, and then they did routine radiographs for certain places, and then additional radiographs if a dancer had pain in an area that was not part of the routine. 'Diagnosis was based on findings from medical histories, physical examinations and radiologic examinations.' No sampling; did not describe their sampling technique at all.	2	n = 42 (0 F); 22.3 yrs avg, 16-3 yrs.	"lumbar spine...injury"	Professional	16/133, 69.6% of the professional group had this injury	16/23 (69.6%)	-	Had a "major skills" chart that tracked central moves and who had these abilities, but that there were no major differences between amateurs and professionals. Relied on dancer memory. 'A limitation of our study was the inability to clarify the correlations between major skills, the specific motion and the injury sites, owing to the small study sample.'	people with injury	Fair II
							Student	5/60, 26.3% of the student group had this injury	5/19 (26.3%)	-			
							Both (full total) 1-8 hrs of training per DAY, avg 4.1 hrs	21/193, 50.0% of the total group had this injury	21/42, 50.0%	-			

ten: five for population selection method, two for comparability, and three for the outcome methods. Only five studies scored less than five, however, no study scored higher than seven. Twenty-five studies relied on non-random sampling methods: convenience sampling (twenty-five studies),^{11,13,21,30-32,36-38,40-46,48-49,51-57} snowball sampling (two studies),^{25,58} volunteer sampling (five studies),^{39,40,48,50,59} or a combination; one study did not describe their sampling technique at all.⁶¹ The lack of random sampling techniques limited the robustness of the reviewed research and prevented any study from gaining a full score.

Data Reporting

Conclusive results for the prevalence of LBP and/or LBI were unable to be calculated because of the difference in data reporting between studies. Sixteen studies^{13,21,25,30,31,36-40,48-49,51,57,59,61} reported how many dancers of the total population studied complained of low back pain/injury (LBP/I), while the other eighteen studies^{11,32,41-47,50-51,53-56,60-61} calculated what percentages of their total pains/injuries were LBP/I.

Ballet Dancers

Twenty-five studies^{11,13,21,25,30-32,36-53} examined LBP/I in ballet dancers. Of the 25 articles, six scored grades of “Good I”, sixteen scored “Fair II”, and three scored “Limited III” using the ADA scoring system. Risk of Bias scores ranged from 3-7 and averaged 5.6/10. Sample sizes ranged from 24 participants⁵¹ to 476 participants,¹¹ with three studies^{30,31,52} having female-only populations, and seven studies^{11,21,36-37,42-43,45} dividing their LBP/I results by gender. Quantifiable activity level was not reported for seven studies,^{25,38-39,42,46,51-52} and those that did provide activity level, typically in hours per week, varied substantially from one another (the range for those that reported activity level in hours per week was 3.9+/-1.5 hours/week to 40-50 hours/week).

Eighteen^{21,25,30-32,36-40,44-49,51-52} of these studies used questionnaires as a data collection tool. Studies could not be directly compared due to the differences in both collection methods and data reporting (Table 6). The studies seem to agree that ballet dancers do experience LBP with an average of 57% prevalence (range of dancers with LBP: 20.3%-79%, range of what percentages of all injuries were LBP: 5.19%-36.6%) and sustain LBI (range of dancers with LBI: 5.3%-22.6%, range of what percentages of all recorded injuries were LBI: 2.1%-88.0%). The number of ballet dancers with LBP specifically in these studies trended towards 2 out of every 3 dancers experiencing LBP (median: 62%, mean: 57%).

Table 6: Reporting Methods in studies examining Low Back Pain and Injury Reports in Ballet Dancers

Data reported as: *	LBP/I values:	Range:
People with LBP (12)	71%, 32.3%, 78%, 50%, 60.7%, 74%, 79%, 73%, 74%, 33%, 20.3%, 62%, 43%	20.3% - 79%
Number of LBPs (4)	9.5%, 5.19%, 36.6%, 8.5%	5.19%-36.6%
People with LBI (1)	22.6%, 5.3%	5.3% - 22.6%
Number of LBIs (8)	88%, 20%, 2.1%, 17.9%, 13.6%, 5.8%, 20.3%, 13.3%, 23.0%	2.1%-88%

* parentheses indicate number of articles who reported in this way.

Modern Dancers

Five studies⁵⁴⁻⁵⁸ examined LBP/I in modern dancers. Of these articles, two scored “Good I” and three scored “Fair II” using the ADA scoring system. Risk of Bias scores ranged from 4-7 and averaged 5.6/10. Sample sizes ranged from 22 participants⁵⁷ to 444 participants,⁵⁴ with one study⁵⁵ dividing their LBP/I results by gender. Quantifiable activity level was not reported for one study.⁵⁶

Four⁵⁵⁻⁵⁸ of these studies used questionnaires as a data collection method. Studies could not be directly compared due to the differences in both collection methods and data reporting (Table 7). The five studies, which all examined a population of modern dance students, seem to agree that LBP/I exist, but its LBP prevalence of 27.3%,⁵⁷ the 8.7%⁵⁴ LBP of total pains, and the LBI prevalence of 15.6% (range: 8.6%-21.6%) are much lower than the ballet studies.

Table 7: Reporting Methods in studies examining Low Back Pain and Injury Reports in Modern Dancers

Data reported as: *	LBP/I values:	Range:
People with LBP (1)	27.3%	27.3%
Number of LBPs (1)	8.70%	8.70%
People with LBI (0)	-	-
Number of LBIs (3)	8.6%, 14.3%, 16.7%, 21.6%, 17%	8.6% - 21.6%

* parentheses indicate number of articles who reported in this way.

Hip-Hop Dancers

Three studies⁵⁹⁻⁶¹ examined LBP/I in hip-hop dancers. All three articles scored “Fair II” using the ADA scoring system. Risk of Bias scores ranged from 5-7 and averaged 6.3/10. Sample sizes ranged from 42 participants⁶¹ to 232 participants,⁶⁰ with one study⁵⁹ having an all-female population, and another study⁶¹ having an all-male population. Quantifiable activity level was not reported for one study.⁶⁰

All three of these studies used questionnaire as their data collection method. Studies could not be directly compared due to the differences in both collection methods and data reporting (Table 8). The three studies seem to agree that LBP/I exist, but its LBP prevalence averaged 61.1% prevalence (range: 46.6-85.7%) and LBI prevalence of 49.0% (range: 26.3%-69.6%) are much higher than the modern dance studies, with values closer to that of the ballet dance studies. The number of hip-hop dancers with LBP specifically trended towards 2 out of every 3 dancers experiencing LBP (median: 56.0%, mean: 61.1%).

Table 8: Reporting Methods in studies examining Low Back Pain and Injury Reports in Hip Hop Dancers

Data reported as: *	LBP/I values:	Range:
People with LBP (1)	46.6%, 55.9%, 56.2%, 85.7%	46.6%-85.7%
Number of LBPs (0)	-	-
People with LBI (1)	69.6%, 26.3%	26.3%-69.6%
Number of LBIs (1)	7%, 8%	7-8%

* parentheses indicate number of articles who reported in this way.

Discussion:

Our primary findings were that not enough LBP/I data exist, particularly for modern and hip-hop dancers, and that clear injury definitions and more descriptive statistics surrounding participant demographic (gender, exposure hours, primary dance genre) are needed. Many studies used professional ballet dancers as their population of study, and very few studies had modern or hip-hop dancers as participants. We discovered a large range of incidence between studies, and a high risk of recall bias with many studies relying on questionnaires. Our study found risk of bias scores to be low, with no study scoring higher than seven out of ten, and twenty-five studies relied on non-random sampling methods. This limitation was present in the majority of dance research on LBP/I, and we hypothesize this is due to the convenience of having many dancers present as part of a dance company or university dance program; collecting data becomes simpler and the participation rate presumably higher when all of the population is in the same place at the same time, or participation in the study can be supported by a company or program director. However, this convenience pitfall also reduces the robustness of the research and should be reduced in future research to adequately address risk of bias. This will lend confidence to the acquired results, and we predict that a reduced risk of bias will shrink the large range of results for LBP/I in dancers over time.

Differences in data collection and presentation

Despite the limited robustness and large range of results, it would seem that ballet and hip-hop dancers are at risk for LBP/I, we were unable to directly compare studies because of the differences in data collection and reporting. Data collection methods for pain/injury data varied, with sixteen studies reporting the number of pains/injury and seventeen studies reporting the number of people with pain/injury across all three dance genres in the present reviews. For example, twelve ballet studies surveyed how many dancers had back pain, while four ballet studies surveyed how many instances of back pain occurred in a certain time frame; this made processing the data difficult without subdividing it for purposes of comparison. Vast differences in collection and reporting methods prevented even the most general comparisons to be made about the prevalence of back pain. Variation in types of questionnaires, screening methods, collection methods, interview questions, and differing injury definitions made determining prevalence difficult.

Baker *et al.*⁵⁵ discussed the contrast between self-reported and reported injuries in contemporary dance students. They suggest that there was a difference in how dancers and physiotherapists classify injury. However, Ramel *et al.*³⁸ administered a Self-Estimated Functionality Inability because of Pain (SEFIP) survey for areas of pain to ballet dancers, and then completed a test battery to confirm the results of the survey. They found that there was good agreement between where the dancers cited current pain and where the physical examinations indicated sites of pain, but the study did not address pain intensity during the physical examinations.

Additionally, some researchers did not include any quantitative level of dance activity, which further complicates directly comparing any two studies. For example, Ramkumar *et al.*⁴¹ reported that their professional ballet population danced an average of 27.5 hours per week (injury incidence of 0.65 per 1000 hours), excluding dress rehearsals and performances. In comparison, Arendt *et al.*³² found that most of their professional ballet population danced 45-50 hours per week (number of weeks per year was unspecified in the study, but assuming a 44 week contract, injury incidence per 1000 hours would be 3.27-2.95). Each studio, university, conservatory, and professional dance company has differing schedules and demands, so it is unsurprising that the level of activity might differ, even amongst professional ballet dancers. As developing research suggests, there may be a correlation between hours of dance activity and rate of injury.⁶² Thus, noting the dance exposure hours instead of, or in addition to,

the experience level of a given dance population will allow for more direct comparisons between populations.

Overall, dancers appear to be at significant risk for LBP, and an increased risk of LBI, although the risk seems higher for dancers who specialize in ballet and hip-hop rather than modern dancers. Of greatest concern to trainers and medical professionals is identifying if their dancers have additional risk. By addressing trends in LBP/I within levels of mastery, age, and gender, it may be possible to determine those dancers who may be at risk of LBP/I before the onset of LBP/I.

Secondary Objectives:

Level of Mastery

Secondary objectives of this review included assessing trends in LBP and LBI along the dancers' level of mastery. Overall, sport research seems to agree that athletes who have increased exposure or intensity have more injuries than those who do not.⁶³ Studies of athletes like gymnasts seem to suggest that LBP is linked to increased exposure hours,⁶⁴ leading to the hypothesis that dancers may also see this trend. No trends could be definitively stated for LBP/I and level of mastery. From the limited amount of research available, professional hip-hop dancers seems to be at more of a risk than those with less mastery, yet both modern and ballet results were too inconsistent to present any trends.

When possible, the original researchers' categorizations were used. Otherwise, we used three arbitrary categorizations, based on the amount of dance (rehearsals, classes, performances) completed on an average week that fit the majority of full-text articles: Student (<15 hours per week), Pre-Professional (>15 hours per week), and Professional (hired by a "professional company"). Ten studies did not provide some measure of dance exposure or typical workload. The studies that did specify exposure varied in their classification of these exposures; for example, professional dancers were reported to have between 27.5⁴¹ to 45-50³³ hours of ballet training per week, or giving no measures other than stating they were "professionals with a full workload".³⁹

Some studies added in a Teacher category that was separate from both Students and Professionals. Previous research has indicated differing demands on the body between dance classes, rehearsals, and performance,⁶⁵ and indicating the ratio of these three items can ease comparison across multiple studies in the future. Further research should include demographics that give a sense of the rigor and duration of dancing, not just titles like 'student' or 'professional', to account for the differences in dance programs, performance seasons, and dance genres. This supports the need for dance activity levels and exposure hours to be included in future research.

Age

Reviews of sport literature agree that children and adolescents seem to be at risk for sport-related injuries,⁶⁶ with theories that physical and physiological differences many account for these high rates, and decreasing their vulnerability with age and maturation.⁶⁷ However, for LBP specifically, which sport changes the relationship between LBP/I risk and age. Several studies have found that young athletes generally are at a higher risk of LBP than adults, although the causes may differ.⁶⁸ This contrasts results in gendered sports like rhythmic gymnasts, Dance Sport, and similar disciplines where there is an increased their risk of LBP with age.⁶⁹⁻⁷²

We were unable to determine a conclusive link between certain ages and risks for LBP/LBI from the results of this study. Studies did not specify the age range of those dancers who either became injured or had endured/still endure back pain; demographics for the general population were provided, but none for those dancers that actually endured LBP or LBI. This again calls for more research into age and LBP/I for dance in general, and specifically ballet, modern, and hip-hop dance.

Gender

None of the eligible hip-hop dance studies provided separate data on males and females with LBP/LBI. Additionally, we were unable to discern clear gender trends amongst the modern dance studies, as only one reported data separately. Sport research does not have copious amounts of analogous research, comparing males and females who specialize in different sports rather than the same sport or aggregating multiple sports or multiple injury cites together.⁷³⁻⁷⁵ They found similar rates of LBP/I, and differences that were not statistically significant in most cases.

Aggregating sports or injury cites would negate any differences between males and females in the same sport or in sports that have “gendered roles”. Miletic *et al.*⁷² found that male international Dance Sport dancers had more hip pain than female dancers, suggesting differences in male and female roles. Male and female gymnasts seem to display anthropometric differences⁷⁶ and may be considered to have “gendered roles”, as male and female gymnasts participate in different gymnastic events. For gymnastics, more research is needed into injury differences in relation to gender, specifically for LBP/I. For dance research, Dance Sport seems to indicate anthropomorphic gender differences as well,⁷⁷ but gendered injury results are scarce, as standardized measures and overall research into Dance Sport injuries are lacking.⁷⁸

Dance research also lacks standardization; Baker and researchers,⁵⁵ indicated that 3 of their 56 female injuries were “lower back injuries” and 3 of their 14 male injuries were “lower back injuries” as reported by the dancers; however, 8 of 52 injuries and 1 out of 11 injuries were reported by physiotherapists for that same time period. Because the dance students and the physiotherapists in that study are not perfectly aligned in their injury definitions, it is difficult to make definitive statements on the role that gender plays in putting modern dancers at risk for LBP/LBI.

Seven of the 25 ballet studies differentiated between males and females; those studies which did find very little discrepancy, which was unexpected, due to the popularity of gendered roles in ballet, as many ballet pieces traditionally have a male and female role with different physical requirements for each. However, due to the significant number of women in ballet as compared to men, the male sample sizes were noticeably smaller than their female counterparts. More research into gender differences should be included in future studies of injury and pain in dancers of any genre, but especially if that dance discipline tends to have differences in expectations for a “male role” and a “female role”.

Limitations & Future Recommendations:

We recognize study limitations. Dance Sport, Flamenco, and other such dance populations were not included in this study, although some research into those dance genres does exist. We excluded those studies who focused on degenerative pathologies, such as spondylosis or degenerative disk disorders; the causes of low back pain in dancers are assumed to be multi-faceted, and thus not addressed in most of the research into back pain and injuries. While the research recognizes that degenerative pathologies most likely constitute some of the dancers who claimed to have back pain or injury within the included studies, a skew in these data may have occurred due to the exclusion of chronic diseases.

Future studies should include the time frame are assessed for pain/injury, and researchers should obtain both the number of complaints and how many people have these complaints to aid comparison across multiple studies on this topic. The majority of studies used in this review included pain or injury questionnaires. Questions such as, “Have you had back pain in the last year?”, asked dancers to recall experiences, relying on their memory which can be unreliable, particularly as the level of detail pertaining to injuries increases.⁷⁹ Level of evidence would increase if reliance on memory decreased, however, the discrepancy between self-reporting and medical record reporting needs to be

addressed; it makes one question the validity of performing either a questionnaire or viewing medical reports when trying to assess the “true” prevalence of back pain.

Further studies would benefit from dividing their data by dance exposure hours or similar measurement rather than arbitrary categories like “professional” or “pre-professional”, since agreement on these terms is low even within the same dance genres. Further research in genres other than ballet, including modern and hip-hop dance, are required to provide a comprehensive understanding of LBP/I.

Conclusions:

Our primary objective to determine prevalence of LBP/I in ballet, modern, and hip-hop dancers yielded more questions than answers; a need for more research, particularly with hip-hop and modern dancers as the populations, cannot be understated. However, this research needs to be more easily compared to existing and future research; to aid future researchers, we have compiled the following suggestions for best practices in LBP/I research.

Best Practices in LBP/I Dance Research:

- Future research on low back pain is needed, particularly in non-ballet dance genres, with clear injury definitions. If applicable, the discrepancy between self-reported and reported injuries should be addressed.
- Researchers should record gender differences, particularly if the dance genre utilizes gendered roles.
- Researchers should include the time frame they are assessing for pain/injury and limit the length of time participants are asked to recall information if are using a questionnaire format.
- Researchers should obtain both the number of complaints and how many people have these complaints to aid comparison across multiple studies.
- Gathering data on both low back pain and low back injury when possible would be ideal, as well as defining specific injury definitions used for each complaint.
- Researchers should report how often their population was dancing in objective epidemiological measurements such as dance exposure hours, as opposed to arbitrary categories.

The included studies in this review suggest that the prevalence of LBP/I seems relatively high in ballet dancers, not as likely in modern dancers, and possibly a higher risk in hip-hop dancers, although not enough high-quality research exists on the subject to date. Future studies need a higher level of evidence and a reduced risk of bias. Our research also suggests that ballet dancers are at risk for LBP/I independent of gender, age or level of mastery. There is not enough evidence to draw any conclusions about modern dancers or hip-hop dancers and their relationship to LBP/I currently.

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