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TITLE: INJURIES DURING TRANSITION PERIODS ACROSS THE YEAR IN PRE-PROFESSIONAL AND PROFESSIONAL BALLET AND CONTEMPORARY DANCERS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Objective: To consider the association of injuries with transition periods in the dance year, i.e., when dancers return at the start of the year, and when they transition from rehearsal to performance periods.

Methods: Six electronic databases were searched to November 2019. All English language peer-reviewed studies, of any study design investigating ballet and contemporary pre-professional and professional dance populations were included. Only those studies reporting on the timing of injury were included.

Results: Fifteen cohort and two case-series studies were included. A meta-analysis of seven studies revealed the rate of injuries to be significantly higher for the second and third months (1.52; 95% confidence interval [CI]:1.11-2.08; 1.26; 95%CI:1.07-1.48 respectively) after the return to dance. Two studies report more injuries up to Week 13 of the year. One study showed an increase in injured dancers at three and four weeks after transition from rehearsals to a performance season. Four studies show an increase in injuries at performance times.

Conclusions: Meta-analyses of seven studies shows the second and third months after returning to dance have a significantly higher rate of injuries. More research is needed to quantify training loads in dance. Practitioners should be cognisant of the higher injury rates during periods of transition and consider modifying load, as it is a potential contributing factor.

Keywords: dance; injury prevention; training load; risk factors

1.0 Introduction

Identifying times when injuries occur across the year in dance may help to determine when load management guidelines (Soligard et al., 2016) are most needed to assist in reducing the risk of injury. Injury prevalence has been reported as high as 95% in dance (Hincapie, Morton, & Cassidy, 2008), and Armstrong and Relph (2018) have suggested that future studies in dance should consider which times within a season may be predictive factors.

Changes in training load and competitions have been associated with injury in sports (Drew & Finch, 2016; Eckard, Padua, Hearn, Pexa, & Frank, 2018; Jones, Griffiths, & Mellalieu, 2017), and although this relationship has not been clearly identified in dance (Fuller, Moyle, Hunt, & Minett, 2019), the link between injury and training load intensification (Jones et al., 2017) is relevant. Pre-season and intense training may be a change in training load (i.e., week-to-week change in the intensity or volume of training, or repetition of skills). The change in training load (i.e., a significant increase on the weeks before) may be a greater predictor of injury than the total workload (Hulin et al., 2014; Hulin, Gabbett, Lawson, Caputi, & Sampson, 2016). A call has been made for future research to investigate the latent period between a spike in training load and the onset of injury (Drew & Finch, 2016). Quantifying training loads is in its infancy in dance (Boeding, Visser, Meuffels, & de Vos, 2019; da Silva et al., 2015; Jeffries, Wallace, & Coutts, 2017), where barriers appear to exist regarding the ability to implement the monitoring of training loads within a dance context (i.e., a lack of finances and/or onsite practitioners).

Dancers' training may be observed to change or intensify across the year during 'transition times'; i.e., the transition from rehearsal periods to performance seasons, or returning to dance at the start of the year. Dancers may train or work for nine to ten months of the year (Bronner & Wood, 2017), leaving two to three months of no formal training or work, when deconditioning could possibly occur. Dance performances have greater oxygen demands than dance classes and rehearsals (Wyon, Abt, Redding, Head, & Sharp, 2004), and dancers improve their fitness levels across a performance season, but not during rehearsal periods (Wyon & Redding, 2005). This demonstrates an increase in the intensity of training to transition to performances from rehearsal periods.

This systematic review synthesises and analyses the available literature to quantitatively investigate the relationship of the rate of injury for each month of the year, relative to other months, to consider the proximity of injury occurrence to the return to dance at the start of the year. A secondary aim is to consider the proximity of injury occurrence in the transition from rehearsal to performance periods. Findings will be discussed in relation to intensified training and changes in training load. It is anticipated that times of the training year when dancers are more susceptible to injury will be identified, and thus when load modification injury reduction strategies may be best utilised.

2.0 Methods

2.1 Search strategy and study selection

The search strategy and study selection methodology have been replicated from <X>. Six electronic databases were searched from inception to the 27th of July, 2018, and updated to the 16th of November, 2019. These were: Pubmed, Embase, CINAHL, SPORTDiscus, Scopus, and the Proquest Performing Arts Periodical. The following search terms and limitations were used in Embase: "physical disease'/exp AND ('dancing'/exp OR 'performing arts'/exp) OR (injur* OR pain OR sprain OR strain* OR muscul* NEXT/1 dis* AND (danc* OR ballet)) AND [humans]/lim AND [english]/lim AND [priority journals]/lim". Identified records were exported to reference management software (EndNote X8, Clarivate Analytics, Philadelphia, 2014), and duplicates removed[4].

Search strategy and study selection were conducted independently by two authors (<X>). A title search was performed, and appropriate titles went to abstract review. Articles were selected for full-text review if the abstract was not available, or if there was a report of injury in a ballet and/or contemporary/modern dance cohort. For the purpose of this investigation contemporary and modern dance genres are grouped together, as they are considered to have more similarities in contrast to ballet, and the combined term of contemporary dance will be used from here onwards. Ballet and contemporary dance are considered to be similar when investigating month to month changes within a year and in the transition from rehearsal periods to performance seasons.

An injury was considered to be any report of musculoskeletal injury, pain presentation, or specific musculoskeletal pathology (e.g., Achilles tendinopathy), and all injury definitions were considered (e.g., time loss, medical attention, and self-report). Only studies reporting on the timing of injuries across part or all of a training year/season were included. Studies were excluded if they investigated other genres of dance (e.g., folk or Broadway), and/or if pre-professional populations were reported to participate in fewer than 20 hours per week of training, and/or if the timing of the injury was not reported across part or all of a training year/season. Reference lists of included papers were searched. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed[32].

2.2 Risk of Bias Assessment

The Newcastle Ottawa Scale for Observational Studies (NOS) (Wells et al., 2000) was used for risk of bias (ROB) assessment of cohort studies and conducted by two independent assessors (<X>). If discrepancies existed between scores, a consensus was then reached via discussion between the two assessors (van Tulder, Furlan, Bombardier, Bouter, & Editorial Board of the Cochrane Collaboration Back Review, 2003).

2.3 Data extraction

Data extracted from the studies included: author; year; country; number of participants; level (pre-professional/professional); dance genre (ballet/contemporary); injury definition; number of injuries (per time period); study design; length of follow-up; and any report of injury across part or all of a training year/season. The month of injury was numbered relative to the return to dance. Where available, the length of the training year was extracted to indicate the length of non-formal work or training. Studies were considered case-series investigations if they did not report on uninjured participants (Mathes & Pieper, 2017). Authors were contacted when clarification was required for interpretation of their investigation, and the authors of studies that did not report on the number of injuries per month were contacted to determine if this could be obtained.

2.4 Data analyses

Characteristics of the studies were summarised. Reports of any association of injury across the training year/season were synthesised for qualitative review. The hierarchy of evidence (Howick et al., 2009), as adapted by Kenny et al. (2016), was considered here to be, in descending order: randomised controlled trials (RCT), cohort studies, case-control studies, cross-sectional studies and case-series.

Studies reporting the number of injuries per month were considered separately for quantitative calculation of rate ratio (RaR) and 95% confidence intervals (CI) (Knowles, Marshall, & Guskiewicz, 2006) of injury for each month relative to other months of the year, using MS Excel v1706 (Microsoft Corporation, Redmond, USA). Statistical significance was accepted at $p<0.05$. RaR for injuries per month for each study were pooled for meta-analysis in Review Manager (RevMan) software (v5.3, The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). The Generic Inverse Variance method with a random-effects model was used, and statistical heterogeneity was determined using the I^2 statistic and guidelines from the Cochrane Handbook (Higgins & Green, 2011) used for interpretation. To address concerns of clinical heterogeneity, subgroup analyses were performed for self-report versus medical attention injury definitions, and pre-professional versus professional cohorts.

3.0 Results

3.1 Search results

In the search, 5649 titles were identified (see Figure 1), of which 2480 titles were duplicates. The update of the search to November 2019 identified a further 331 titles to be searched. Following this, 352 titles went to a full-text screening, and 17 papers were included (Baker, Scott, Watkins, Keegan-Turcotte, & Wyon, 2010; Bronner, Ojofeitimi, & Rose, 2003; Bronner & Wood, 2017; Byhring & Bø, 2002; Gamboa, Roberts, Maring, & Fergus, 2008; Garrick & Requa, 1993; Kenny, Palacios-Derflingher, Whittaker, & Emery, 2018; Lee, Reid, Cadwell, & Palmer, 2017; Liederbach & Compagno, 2001; Liederbach, Dilgen, & Rose, 2008; Ojofeitimi & Bronner, 2011; Solomon, Micheli, Solomon, & Kelley, 1996; Solomon, Solomon, Micheli, & McGray Jr, 1999; van Winden et al., 2019; Wanke, Arendt, Mill, & Groneberg, 2013; Wanke, Koch, Leslie-Spinks, & Groneberg, 2014; Wolman et al., 2013), of which 15 studies were unique datasets, including 13 cohort studies and two case-series investigations.

Three additional papers were included (Kerr, Krasnow, & Mainwaring, 1992; Liederbach, Gleim, & Nicholas, 1994; Solomon, Michelli, Solomon, & Kelley, 1995) from reference list searches, of which two cohort studies were individual. Seven cohort studies (Baker et al., 2010; Gamboa et al., 2008; Garrick & Requa, 1993; Kenny et al., 2018; Lee et al., 2017; Solomon et al., 1996; Solomon et al., 1995; Solomon et al., 1999; van Winden et al., 2019) were included for quantitative analysis. Ten studies, eight cohort (Bronner et al., 2003; Bronner & Wood, 2017; Byhring & Bø, 2002; Kerr et al., 1992; Liederbach & Compagno, 2001; Liederbach et al., 2008; Liederbach et al., 1994; Ojofeitimi & Bronner, 2011; van Winden et al., 2019; Wolman et al., 2013) and two case-series (Wanke et al., 2013; Wanke et al., 2014), were included for qualitative analysis. Data were only included once when there were multiple publications of the same study; however, all publications were included to ensure accurate interpretation of the study (Higgins & Green, 2011). See Table 1 for study characteristics.

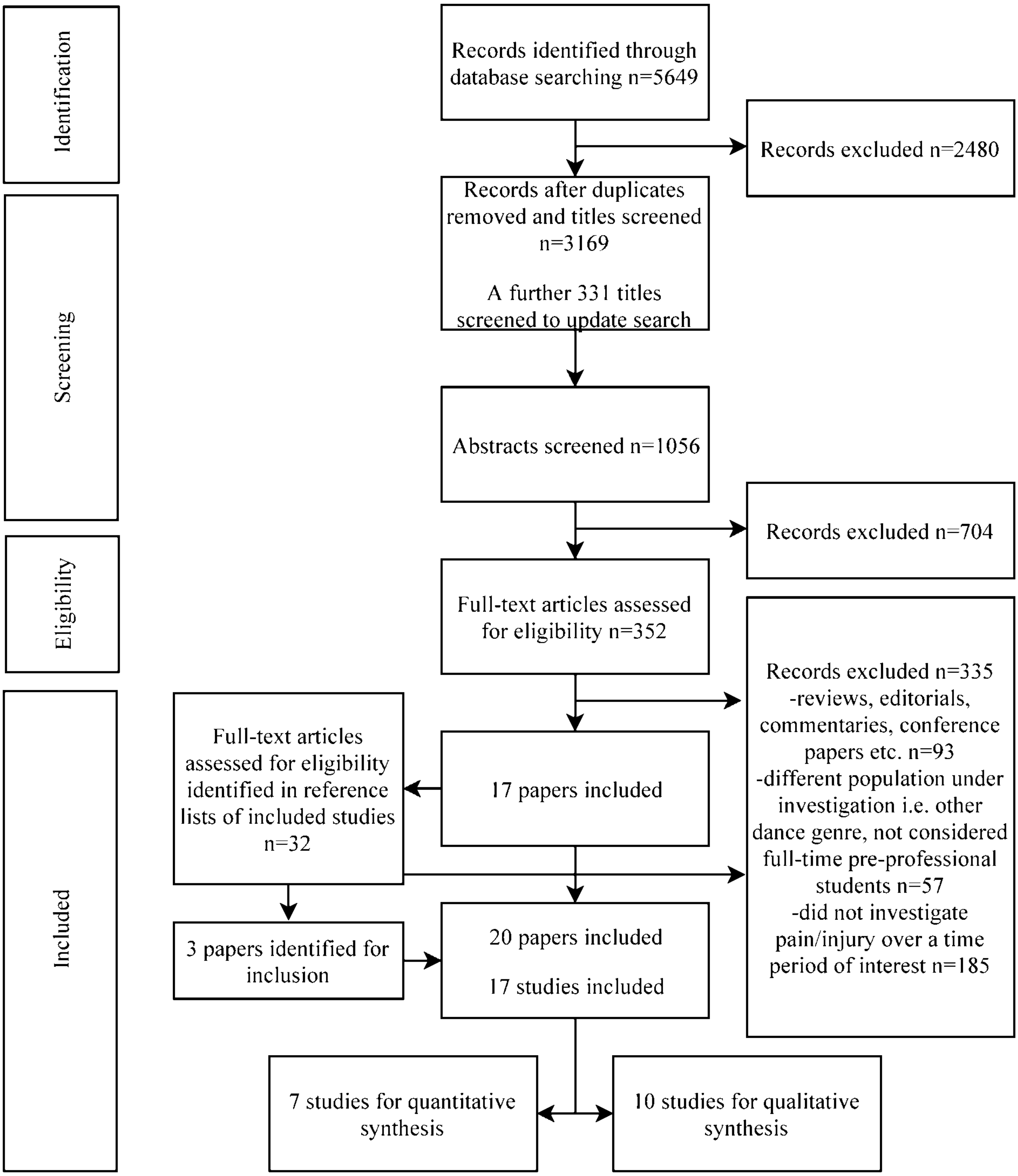


Fig 1. PRISMA (Preferred Reporting Items for Systematic Reviews with Meta-Analyses) flow diagram of the search strategy and study selection

Table 1. Characteristics of included studies.

Study Country	Follow up and months/weeks of the training year	Number (n)	Age (years) [mean (±SD)]	Genre	Level	Injury/Pain definition
Cohort Studies						
Baker et al., 2010 United Kingdom	1 retrospective training year 7.5 months	57 47 female, 10 male	Female 20.0 ± 2.51 Male 21.0 ± 3.00	Contemporary	Pre-Professional	Medical attention Self-report (physical damage that prevented completion of one or more classes)
Bronner & Wood, 2017 United States of America	1 prospective training year 41 weeks	30-32 15 female, 15 male	29.06 ± 5.57 20-41 [range]	Contemporary	Professional	Medical attention Time loss (unable to dance for one or more days)
Byhring & Bo, 2002 Norway	19 prospective training weeks	41 27 female, 14 male	26.7 19-40 [range]	Ballet	Professional	Medical attention
Gamboa et al., 2008 United States of America	5 retrospective training years 9 months each training year	359 288 female, 71 male	14.7 ± 1.9 9-20 [range]	Ballet	Pre-professional	Medical attention
Garrick & Requa, 1993 Unknown	3 retrospective training years 10 months	70 each year + extra dancers employed at different times of the year	Unknown	Ballet	Professional	Medical attention Financial outlay
Kenny et al., 2018 Canada	1 prospective training year 31 weeks contemporary, 40 weeks ballet	145 85 ballet, 77 female, 8 male 60 contemporary, 58 female, 2 male	Ballet 15, 11-19 [range] Contemporary 19, 17-30 [range]	Ballet Contemporary	Pre-professional	Medical attention Self-report (any physical complaint impacting dance participation)
Kerr et al., 1993 Unknown	1 prospective training year 8 months	39	18-25 [range]	Ballet Contemporary	Pre-professional	Self-report (pain or discomfort resulting in cessation or negative impact on training, or interference with concentration)
Lee et al., 2017 New Zealand	1 prospective training year 10 months	66 40 female, 26 male	18.15 ± 1.45 Female 17.78 ± 1.18 Male 18.57 ± 1.72	Ballet Contemporary	Pre-professional	Medical attention
Liederbach et al., 1994 United States of America	5 training weeks	12 6 female, 6 male	Female 24 ± 1 Male 26 ± 2	Ballet	Professional	Medical attention
Liederbach & Compagno., 2001 Unknown	2 prospective training years	644 282 university 123 ballet company, 239 clinic	University 19.7 ± 2.2 Ballet company 24.6 ± 4.9 Clinic 27.8 ± 8.0	Ballet Contemporary	Pre-professional Professional	Medical attention
Liederbach et al., 2008 United States of America	5 prospective training years	298	Unknown	Ballet Contemporary	Pre-professional Professional	ACL injury
Ojofeitimi & Bronner, 2011; Bronner et al., 2003	2 retrospective, and 3-6 prospective training years	42 per year	1st company 27.3 ± 0.3 2nd company 22.3 ± 0.7	Contemporary	Professional	Medical attention

United States of America	41 weeks each training year					Time loss (cease dancing beyond the day of injury) Financial outlay
Solomon et al., 1995; 1996; 1999 United States of America	1-5 training years 9 months each training year	59-70 per year	17-35 [range]	Ballet	Professional	Self-report
Wolman et al., 2013 United Kingdom	2 separate, 4-month blocks within the training year	19	Female 24 ± 4.5 Male 23 ± 2.1	Ballet	Professional	Medical attention Time loss (prevention of full dance activities for 24 hours or more)
van Winden et al, 2019 The Netherlands	1 prospective training year 10 months	130 90 female, 40 male	19.4 ± 1.5	Contemporary	Pre-professional	Self-report (any physical complaint that led to consequences on training)
Case-series studies						
Wanke et al., 2013 Germany	17 training years	785 injuries 358 injuries female 427 injuries male	28.7 ± 5.3 Female 28.9 ± 5.2 Male 28.5 ± 5.4	Ballet	Professional	Medical attention Time loss
Wanke et al., 2014 Germany	2 separate, 2 training year periods (1994-1995 and 2011-2012)	155 injuries (1994-1995) 86 injuries (2011-2012)	28 (1994-1995) 29.5 (2011-2012)	Ballet	Professional	Medical attention Time loss

3.2 Risk of bias assessment

Risk of bias scores ranged from three (Kerr et al., 1992; Liederbach & Compagno, 2001) to seven (Kenny et al., 2018) out of nine. Case-series (Wanke et al., 2013; Wanke et al., 2014) investigations did not receive a risk of bias score and were considered as a lower level of evidence (Howick et al., 2009). See Table 2 for scores of individual studies. All studies received a zero score for comparability, which reveals a lack of controlling for related factors.

Table 2. Risk of bias scores for cohort studies using the Newcastle Ottawa Scale

Study	Selection	Comparability	Outcome	Total
Baker et al., 2010	3	0	2	5
Bronner & Wood, 2017	2	0	3	5
Byhring & Bo, 2002	2	0	2	4
Gamboa et al., 2008	3	0	2	5
Garrick & Requa, 1993	3	0	2	5
Kenny et al., 2018	4	0	3	7
Kerr et al., 1992	2	0	1	3
Lee et al., 2017	3	0	2	5
Liederbach et al., 1994	3	0	2	5
Liederbach & Compagno, 2001	2	0	1	3
Liederbach et al., 2008	3	0	2	5
Ojofeitimi & Bronner, 2011	2	0	2	4
Solomon et al., 1999	3	0	1	4
Wolman et al., 2013	2	0	2	4
van Winden et al., 2019	2	0	2	4

3.3 Meta-analysis

Seven cohort studies were included for meta-analysis (Baker et al., 2010; Gamboa et al., 2008; Garrick & Requa, 1993; Kenny et al., 2018; Lee et al., 2017; Solomon et al., 1999; van Winden et al., 2019) with ROB scores between four (Solomon et al., 1999; van Winden et al., 2019) and seven (Kenny et al., 2018); all other studies scored a five (Baker et al., 2010; Gamboa et al., 2008; Garrick & Requa, 1993; Lee et al., 2017). Two corresponding authors supplied data for these calculations (Kenny et al., 2018; van Winden et al., 2019). RaR was calculated for each month of the year compared with other months of the year. The pooled RaR for each month of the training year after return to dance is shown in Figure 2. Compared with other months of the year, injuries sustained in the third month after return to dance were found to be statistically significant with low heterogeneity (RaR=1.26; 95%CI:1.07-1.48; I^2=6%; see

Figure 3). The study with the highest bias was weighted the highest (Solomon et al., 1999) in this analysis due to a higher number of injuries (see Figure 3). The second month of the year was also statistically significant, but with substantial statistical heterogeneity (RaR=1.52; 95%CI:1.11-2.08; I^2=75%).

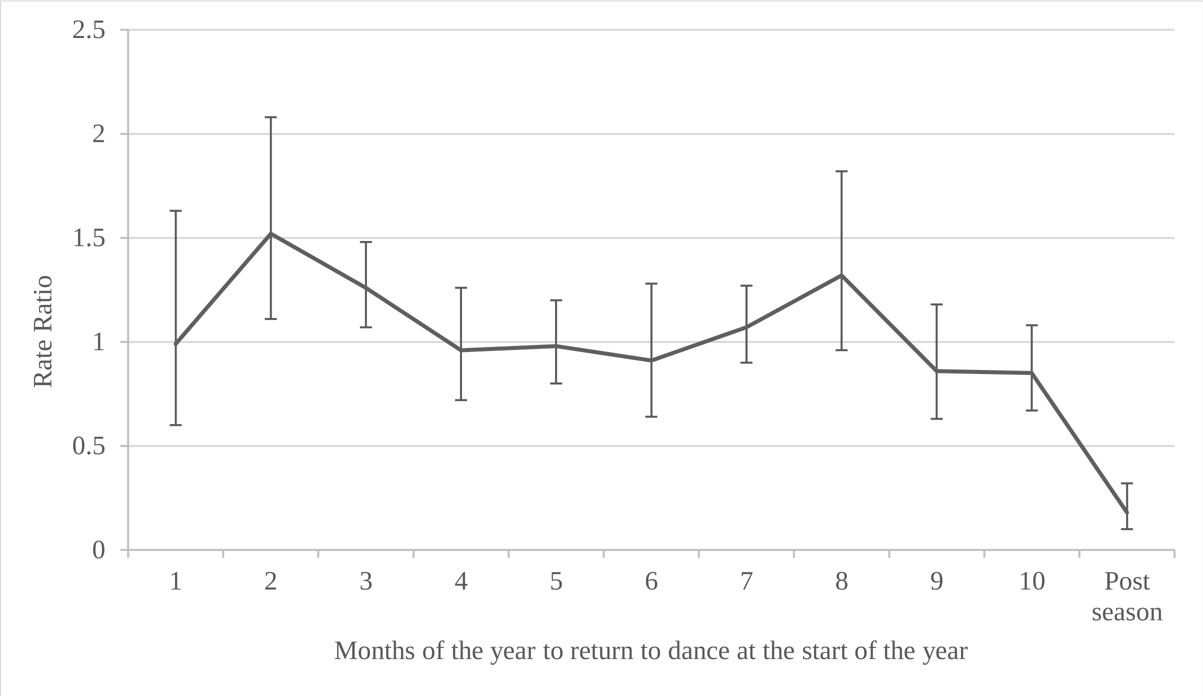


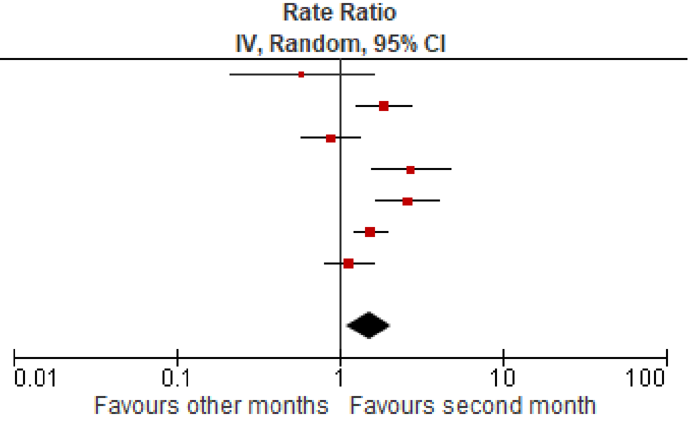
Fig. 2. Pooled rate ratios of injuries for months of the year compared with other months of the year after return to dance at the start of the year for studies included for meta-analysis (Baker et al., 2010; Gamboa et al., 2008; Garrick & Requa, 1993; Kenny et al., 2018; Lee et al., 2017; Solomon et al., 1999; van Winden et al., 2019)

vertical brackets indicate 95% confidence intervals

second month: $p=0.009$, $I^2=75\%$, third month: $p = 0.005$, $I^2=6\%$

Study or Subgroup	log[Rate Ratio]	SE	Weight	Rate Ratio IV, Random, 95% CI
Baker et al., 2010 medical attention injuries	-0.52735493	0.51613316	6.6%	0.59 [0.21, 1.62]
Gamboa et al., 2008	0.63252256	0.19647631	15.9%	1.88 [1.28, 2.77]
Garrick et al., 1993	-0.12260232	0.21673662	15.1%	0.88 [0.58, 1.35]
Kenny et al., 2018 medical attention injuries	1.01856958	0.28588594	12.6%	2.77 [1.58, 4.85]
Lee et al., 2017	0.960829	0.22708513	14.7%	2.61 [1.67, 4.08]
Solomon et al., 1999	0.440217	0.12382168	18.5%	1.55 [1.22, 1.98]
van Winden et al., 2019	0.12825434	0.17688004	16.6%	1.14 [0.80, 1.61]
Total (95% CI)			**100.0%**	**1.52 [1.11, 2.08]**

Heterogeneity: Tau² = 0.12; Chi² = 23.61, df = 6 (P = 0.0006); I² = 75%
Test for overall effect: Z = 2.60 (P = 0.009)



Study or Subgroup	log[Rate Ratio]	SE	Weight	Rate Ratio IV, Random, 95% CI
Baker et al., 2010 medical attention injuries	0.71183931	0.31968932	6.4%	2.04 [1.09, 3.81]
Gamboa et al., 2008	0.38171102	0.21331618	14.0%	1.46 [0.96, 2.23]
Garrick et al., 1993	0.34011523	0.17950227	19.3%	1.41 [0.99, 2.00]
Kenny et al., 2018 medical attention injuries	0.18232156	0.37638633	4.7%	1.20 [0.57, 2.51]
Lee et al., 2017	-0.28484	0.36544084	5.0%	0.75 [0.37, 1.54]
Solomon et al., 1999	0.206637	0.13505087	32.1%	1.23 [0.94, 1.60]
van Winden et al., 2019	0.03077166	0.18378045	18.5%	1.03 [0.72, 1.48]
Total (95% CI)			**100.0%**	**1.26 [1.07, 1.48]**

Heterogeneity: Tau² = 0.00; Chi² = 6.36, df = 6 (P = 0.38); I² = 6%
Test for overall effect: Z = 2.81 (P = 0.005)

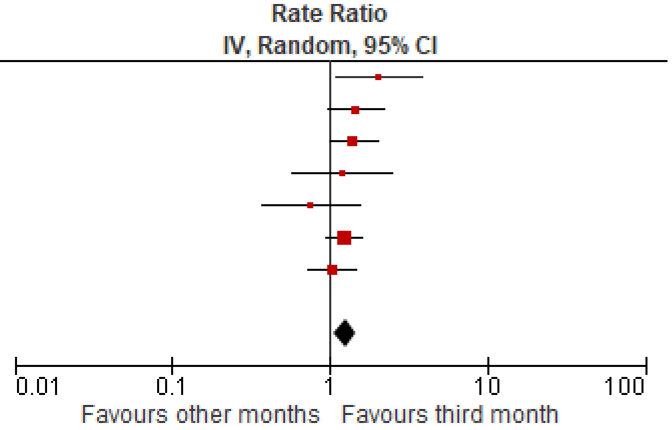
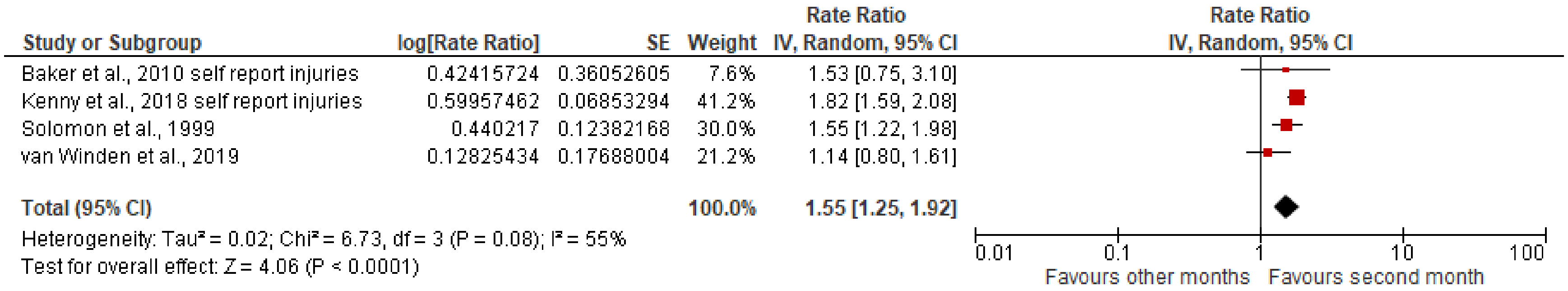


Fig. 3 Forest plot of injury rate ratio for the second and third months of the year relative to the other months of the year

3.3.1 Subgroup analyses

Self-report versus medical attention injury definition subgroup

Four studies used a self-report definition (Baker et al., 2010; Kenny et al., 2018; Solomon et al., 1999; van Winden et al., 2019), and five used a medical attention definition (Baker et al., 2010; Gamboa et al., 2008; Garrick & Requa, 1993; Kenny et al., 2018; Lee et al., 2017). The studies by Baker et al. (2010) and Kenny et al. (2018) utilised both self-report and medical attention definitions. The second (RaR=1.55; 95%CI:1.25-1.92; I^2=55%) and third (RaR=1.19: 95%CI:1.05-1.35; I^2=0%) months of the training year were statistically significant for the self-report injury definition (see Figure 4). The RaR for the third month was statistically significant for the medical attention injury definition (RaR=1.38; 95%CI:1.08-1.75; I^2=11%; see Figure 5).



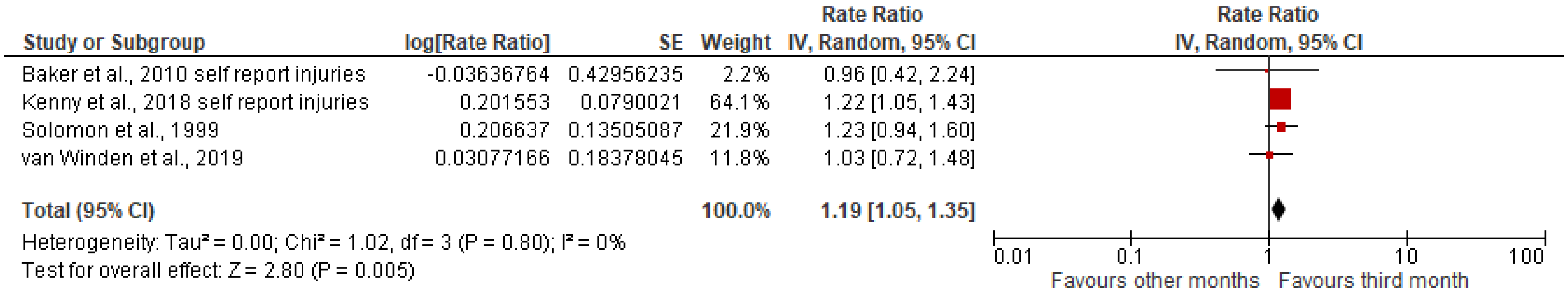


Fig 4. Forest plot for self-report injury subgroup of injury rate ratio for the second and third months of the year relative to the other months of the year

Study or Subgroup	log[Rate Ratio]	SE	Weight	Rate Ratio IV, Random, 95% CI
Baker et al., 2010 medical attention injuries	0.71183931	0.31968932	13.7%	2.04 [1.09, 3.81]
Gamboa et al., 2008	0.38171102	0.21331618	28.1%	1.46 [0.96, 2.23]
Garrick et al., 1993	0.34011523	0.17950227	37.3%	1.41 [0.99, 2.00]
Kenny et al., 2018 medical attention injuries	0.18232156	0.37638633	10.1%	1.20 [0.57, 2.51]
Lee et al., 2017	-0.28484	0.36544084	10.7%	0.75 [0.37, 1.54]
Total (95% CI)			**100.0%**	**1.38 [1.08, 1.75]**

Heterogeneity: Tau² = 0.01; Chi² = 4.47, df = 4 (P = 0.35); I² = 11%
Test for overall effect: Z = 2.60 (P = 0.009)

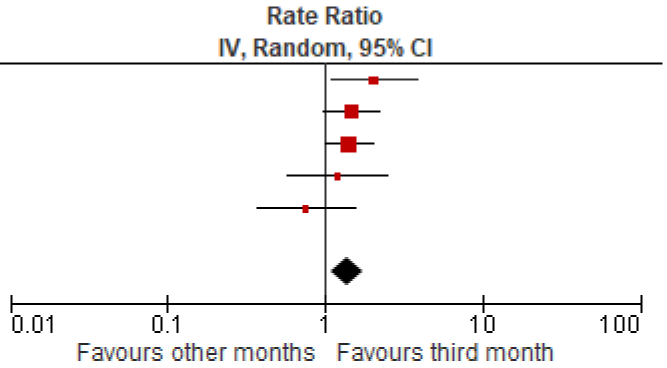


Fig 5. Forest plot for medical attention injury subgroup of injury rate ratio for the third month of the year relative to other months of the year

Pre-professional versus professional subgroup

Five studies investigated a pre-professional cohort (Gamboa et al., 2008; Kenny et al., 2018; Lee et al., 2017; van Winden et al., 2019) and two studies investigated professional cohorts (Garrick & Requa, 1993; Solomon et al., 1999). For the pre-professional subgroup, the second month had a significantly higher RaR of injury, but with substantial statistical heterogeneity (RaR=1.69: 95%CI:1.09-2.62; I^2=75%; see Figure 6). The third and eighth months had significantly higher RaR of injury for the professional subgroup (RaR=1.29: 95%CI:1.04-1.59; I^2=0% [third month]; RaR=1.93: 95%CI:1.14-3.28 [eighth month]; see Figure 7). The tenth month had a statistically lower RaR of injury for the professional subgroup (RaR=0.72: 95%CI:0.55-0.94; I^2=0%).

Study or Subgroup	log[Rate Ratio]	SE	Weight	Rate Ratio IV, Random, 95% CI
Baker et al., 2010 medical attention injuries	-0.52735493	0.51613316	11.3%	0.59 [0.21, 1.62]
Gamboa et al., 2008	0.63252256	0.19647631	23.3%	1.88 [1.28, 2.77]
Kenny et al., 2018 medical attention injuries	1.01856958	0.28588594	19.4%	2.77 [1.58, 4.85]
Lee et al., 2017	0.960829	0.22708513	22.0%	2.61 [1.67, 4.08]
van Winden et al., 2019	0.12825434	0.17688004	24.1%	1.14 [0.80, 1.61]
Total (95% CI)			**100.0%**	**1.69 [1.09, 2.62]**

Heterogeneity: Tau² = 0.18; Chi² = 16.15, df = 4 (P = 0.003); I² = 75%
Test for overall effect: Z = 2.36 (P = 0.02)

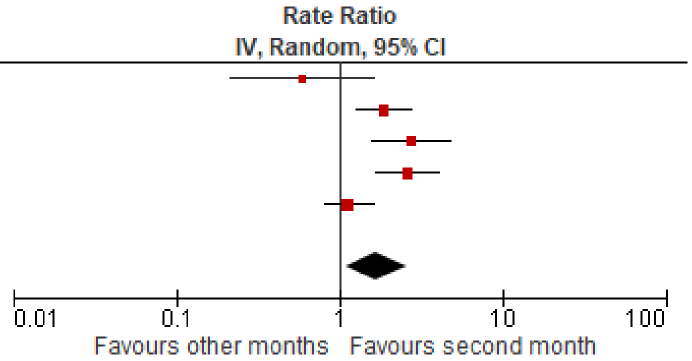
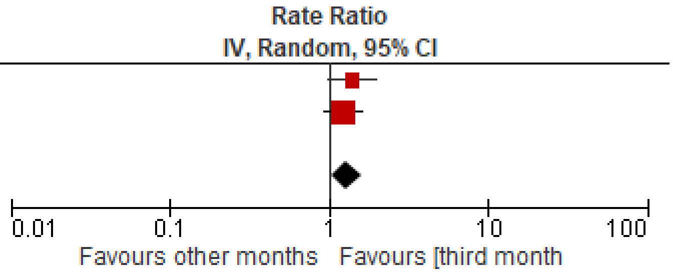


Fig 6. Forest plot for pre-professional subgroup of injury rate ratio for the second month of the year relative to the other months of the year

Study or Subgroup	log[Rate Ratio]	SE	Weight	Rate Ratio IV, Random, 95% CI
Garrick et al., 1993	0.34011523	0.17950227	36.1%	1.41 [0.99, 2.00]
Solomon et al., 1999	0.206637	0.13505087	63.9%	1.23 [0.94, 1.60]
Total (95% CI)			**100.0%**	**1.29 [1.04, 1.59]**

Heterogeneity: Tau² = 0.00; Chi² = 0.35, df = 1 (P = 0.55); I² = 0%
Test for overall effect: Z = 2.36 (P = 0.02)



Study or Subgroup	log[Rate Ratio]	SE	Weight	Rate Ratio IV, Random, 95% CI
Garrick et al., 1993	0.93288534	0.14568954	49.1%	2.54 [1.91, 3.38]
Solomon et al., 1999	0.393442	0.12593037	50.9%	1.48 [1.16, 1.90]
Total (95% CI)			**100.0%**	**1.93 [1.14, 3.28]**

Heterogeneity: Tau² = 0.13; Chi² = 7.85, df = 1 (P = 0.005); I² = 87%
Test for overall effect: Z = 2.44 (P = 0.01)

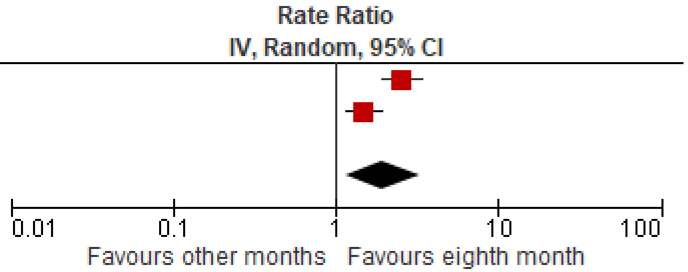


Fig 7. Forest plot for the professional subgroup of injury rate ratio for the third and eighth months of the year relative to other months of the year

3.4 Evidence in support of injuries occurring at specified times from individual studies

After return to dance at the start the year

As calculated here, beyond the meta-analysis findings, a higher rate of injury was seen quantitatively for the first month in the individual studies by Lee et al. (2017) (RaR=2.35; 95%CI:1.48-3.72) and Kenny et al. (2018) (RaR=2.26; 95%CI:1.28-4.02). Three studies (Bronner et al., 2003; Byhring & Bø, 2002; Ojofeitimi & Bronner, 2011) reported increased injury occurrence in the first two months to 13 weeks after return to dance at the start of the year.

When transitioning from rehearsal periods to performance seasons

Calculations made here show that the study by Garrick and Requa (1993) had significantly higher RaR for the sixth month (RaR=1.68; 95%CI:1.21-2.34) when their performance season reportedly commences. Calculations made here for the study by Solomon et al. (1999) show a 55% (95%CI:1.22-1.98) increased RaR of injury for the second month when their performance season reportedly commences. Two further studies (Bronner & Wood, 2017; Liederbach et al., 1994) report an increased injury occurrence in proximity to performance seasons.

3.5 Evidence not supporting injury occurrence after return to dance at the start the year

From calculations made here, the eighth month of the year had a statistically higher RaR for the studies by Garrick and Requa (1993) and van Winden et al. (2019) (see Figure 7), and increases were not seen for the first three months in these two studies. Three cohort studies (Kerr et al., 1992; Liederbach et al., 2008; Wolman et al., 2013) and two cross-sectional studies (Wanke et al., 2013; Wanke et al., 2014) reported increased injury occurrence in later months of the year.

4.0 Discussion

4.1 Meta-analysis of rate ratio of injury for each month of the year

This review synthesised and analysed literature investigating when injuries occur across the year in dance, specifically when returning to dance at the start of the year and when transitioning from rehearsal to performance periods. Where possible, the RaR for injury for each month of the training year has been calculated for individual studies and compared with other months of the year. The meta-analysis of seven cohort studies, investigating pre-professional and professional ballet and contemporary dancers, showed significantly more injuries in the third month after returning to dance at the start of the year (26%; p=0.005; I^2=6%). The second month of the year also reached statistical significance, but with substantial statistical heterogeneity (52%; p=0.009; I^2=75%), meaning differences exist between the RaR of the pooled studies.

This increase in injuries in the second and third months of the training year may represent a latent response to the increase in training when transitioning to full training hours. A latent response to injury has been shown three to four weeks after a spike in training load in cricket fast bowlers (Orchard et al., 2015; Orchard, James, Portus, Kountouris, & Dennis, 2009). It is possible that the latent injury response shown here in the second and third months might have occurred earlier than indicated. If the exposure had been measured more narrowly, in weeks instead of months, it might have indicated earlier injuries, since it is not known how many weeks of dance there were in the first month of the year. Subgroup analyses to address concerns about clinical heterogeneity of self-report versus medical attention injury definitions, and pre-professional versus professional cohorts, support significantly increased RaR for the second and third months (see Figures 4 to 7).

4.2 Injuries after return to dance at the start of the year for individual studies

The included study with the least risk of bias (Kenny et al., 2018) (ROB=7) showed significantly increased rates of injury for the first and second months after return to dance, as did Lee et al. (2017) (ROB=5) Kenny et al. (2018) excluded currently injured participants, included only dance-related injuries, and had adequate follow-up of participants, giving the reader greater confidence in the findings from their study as applied to the research question of this systematic review. Participants in the study by Baker et al. (2010) (ROB=5) commenced technique classes midway through the second month, so the significant increase in injuries in the third month of the year could be a result of this timing. It is not reported if this involved an increase in training hours. It can be speculated that to commence technique classes involves more dance specific movement repetition when compared to modes of supplemental training that may relate to the increase in injuries seen in this study.

Two of the seven studies for meta-analysis (Garrick & Requa, 1993; van Winden et al., 2019) (ROB=4 and 5) did not reveal significantly higher RaR for the first three months from calculations made here. It should be noted that the study by Garrick and Requa (1993) reported a variable number of dancers working with the company at different times of the year, which could influence the rate of injury when considering the number of injuries and not the number of dancers injured, the latter of which is not investigated here. The findings by Garrick and Requa (1993) could also be considered separately because their definition of injury includes a financial outlay. It is not known why the RaR for injuries was not higher for the first three months in the study by van Winden et al. (2019), but this study did have a higher risk of bias (ROB=4)

Bronner et al. (2003) (ROB=4) report 37% of injuries occurred in the first ten weeks of their 40-week contract year. Ojofeitimi and Bronner (2011) (ROB=4) report in their follow-up paper that 48% of injuries occurred in the performance weeks, and thus it can be inferred that

52% of injuries occurred during their 11–13 week rehearsal period to commence the year, representing 29% of the training year. Byhring and Bo (2002) (ROB=4) report that 59.4% of injuries occurred in the first two months of the year of a 19-week study. A further cohort study (Liederbach et al., 2008) (ROB=5), only including anterior cruciate ligament injuries, showed these injuries occurred mid to late in the season. This finding, which uses a traumatic injury definition, could be considered separately. These findings show an association with injury and returning to dance at the start of the year.

4.3 Injuries during the transition from rehearsal periods to performance seasons

Liederbach et al. (1994) (ROB=5) showed that 33% and 66% of the dancers in their study were injured in the third and fourth weeks respectively of a five-week performance season, after transitioning from a rehearsal period. This latent injury presentation is of the same time frame reported in cricket, of three to four weeks after a change in training load (Orchard et al., 2015; Orchard et al., 2009). From our calculations, the studies by Solomon et al. (1999) (ROB=4) and Garrick and Requa (1993) (ROB=5) showed an increased RaR of injury in proximity to the commencement of their performance seasons, but a potential increase in the number of dancers could also influence this, reported in the study by Garrick and Requa (1993). In pre-professional dancers, injuries coincide with performance periods (Kenny et al., 2018) (ROB=7), and Bronner and Wood (2017) (ROB=5) showed an increase in time-loss injuries during two separate performance periods. The performance periods were 28 and 34 days (0.29 and 0.14 injuries/1000 hours respectively) following rehearsal periods (0.08 injuries/1000 hours). These findings show an association with injury when transitioning from rehearsal to performance periods.

4.4 Other possible transitions associated with injury across the year in dance

Other possible transitions, not investigated here, may be identified as occurring across the year in dance. Included studies have reported that injuries occur in proximity to assessment periods (Baker et al., 2010), also seen in college football players (Mann, Bryant, Johnstone, Ivey, & Sayers, 2016). Another included study reports on the impact of touring on injuries (Bronner & Wood, 2017).

4.5 Limitations

Some limitations should be recognised when interpreting the findings of the current review. Unpublished literature was not searched, which may have led to publication bias, and a low number of studies were pooled for meta-analysis. The included studies did not account for the duration or intensity of training workload at different times of the year, and the review has made inferences regarding intensified periods of training, due to the lack of evidence quantifying workload. For included studies in the meta-analysis, all reported months of the training year were included when calculating RaR for each study. However, it is not always clear how much dance exposure there was for each month, as some months may have had fewer weeks of training.

Just two studies (Kenny et al., 2018; Liederbach et al., 2008) reported on the presence of injury at the commencement of the study and few included studies reported adequately on follow-up within the cohort — for instance, a different number of individuals exposed to possible injury could exist for different months of the year, as seen in the study by Garrick and Requa (1993). This has introduced bias into the interpretation of studies. The included studies that reported on injuries at periods across the year mostly reported on injuries per month, with two studies (Kenny et al., 2018; Liederbach et al., 1994) considering injuries weekly. A narrower exposure measure would refine the time periods of when injuries occur.

4.8 Future research

Future research in dance would benefit from using consistent definitions of injury, quantifying workloads to take into account the intensity of training and repetition of skills, and narrowing exposure measures from monthly to weekly injury surveillance. Research in sport has demonstrated latent presentations of injury after spikes in workload (Orchard et al., 2015; Orchard et al., 2009), for consideration by the dance community. Statistical analysis would benefit from accounting for confounders such as previous injury, training history, fitness parameters, temporal influences, and other possible transitions across the year in dance.

5.0 Conclusion

This systematic review identifies when injuries occur across a training year in dance. A meta-analysis of seven studies showed an increased rate of injuries for the second and third months of the training year. Subgroup analyses demonstrated that a spike in self-reported injuries in the second and third months (Baker et al., 2010; Kenny et al., 2018; Solomon et al., 1999) of the training year was followed by a spike in medical attention injuries in the third month (Baker et al., 2010; Gamboa et al., 2008; Garrick & Requa, 1993; Kenny et al., 2018; Lee et al., 2017). Further subgroup analyses reveal higher rates of injury in the second month, and third and eighth months for pre-professional and professional cohorts respectively. Further to these findings, two studies reported that injuries occurred in the first two months through to Week 13 of the training year, although six of the 17 included studies (two lower hierarchy case-series studies, and the lowest ROB scores for cohort studies) did not support this finding. One study showed an increase in injury presentations at three and four weeks when transitioning from a rehearsal period to a performance season. Four studies showed an increase in injuries related to performance seasons. However, the reader is reminded that the studies did not control for other factors affecting these associations with injury.

Dance practitioners may consider modifying training loads during return to dance at the start of the year, and during the transition from rehearsal to performance periods. More research is needed to quantify training loads and narrow exposure measures, that is from months to weeks, for injury surveillance in dance.

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