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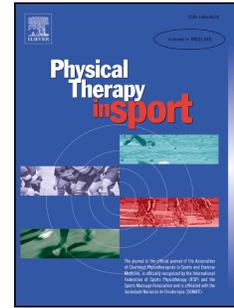
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The prevalence and impact of low back pain in pre-professional and professional dancers: a prospective study

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1 **The prevalence and impact of low back pain in pre-professional and professional**
2 **dancers: a prospective study**

3

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11 **The prevalence and impact of low back pain in pre-professional and professional**
12 **dancers: a prospective study**

13 **Structured Abstract**

14 Objectives: To determine the prevalence of low back pain (LBP) in pre-professional and
15 professional dancers and its impact on dance participation, care-seeking and medication
16 use.

17 Design: Prospective cohort study

18 Setting: One pre-professional ballet school, two pre-professional university dance programs,
19 and a professional ballet company.

20 Participants: Male and female classical ballet and contemporary dancers

21 Main Outcome Measures: An initial questionnaire collected demographic and LBP history
22 data. The monthly prevalence of LBP (all episodes, activity limiting episodes and chronic
23 LBP) and impact (activity limitation, care-seeking, and medication use) was collected over a
24 nine-month period.

25 Results: 119 dancers participated, which represented 54% of those invited. Activity limiting
26 LBP was reported by 52% of dancers, while chronic LBP was reported by 24%. Seventeen
27 percent of all episodes of LBP resulted in some form of dance activity being completely
28 missed. One-third of the sample reported care-seeking and one-fifth of the sample used
29 medication. A history of LBP was associated with activity limiting LBP ($p < 0.01$; adjusted
30 odds ratio: 3.98; 95% confidence interval: 1.44, 11.00).

31 Conclusions: LBP in dancers was common and had multiple impacts. This study reinforces
32 the need for dancer access to healthcare professionals with expertise in evidence-based
33 LBP prevention and management.

34 **Key words**

35 Epidemiology; Pain experience; Spine; Dance

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36 **Highlights**

- 37 • Prevalence of LBP in dancers is similar to those reported in other elite sport
- 38 • A high degree of variation exists between LBP experience and impact on
- 39 participation
- 40 • Past history of LBP increases future risk

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43 Introduction

44 Low back pain (LBP) is the leading cause of disability worldwide and represents significant
45 personal and social cost (Maher, Underwood, & Buchbinder, 2017). It is often first
46 experienced in childhood, with lifetime prevalence reaching adult levels by late adolescence
47 (Calvo-Munoz, Gomez-Conesa, & Sanchez-Meca, 2013). Dance, which is a rigorous
48 physical pursuit that boasts the highest participant rate for all cultural, sporting and leisure
49 activities amongst Australian girls and the second highest for Australian male and female
50 children combined (ABS, 2012), has been associated with a high prevalence of LBP
51 (Crookshanks & Trotter, 1999; McMeeken, et al., 2001; Swain, Bradshaw, Whyte, &
52 Ekegren, 2017). There is a strong rationale underlying this correlation. For instance,
53 epidemiological evidence shows that engaging in work with high physical demands is a risk
54 factor for the initial onset of LBP (Ferguson & Marras, 1997), while specific spine movements
55 such as repetitive bending and twisting, which are integral to dance, are associated with
56 increased reports of LBP as well as functional loss and spine injury (Ferguson & Marras,
57 1997; Marras, Lavender, Ferguson, Splittstoesser, & Yang, 2010).

58 Accordingly, epidemiological studies of dance injuries have identified the low back as the
59 third most common site of injury in both pre-professional and professional classical ballet
60 dancers (Allen, Nevill, Brooks, Koutedakis, & Wyon, 2012; Ekegren, Quested, & Brodrick,
61 2014), and the second most common site of chronic injury in Australian professional dancers
62 (Crookshanks & Trotter, 1999). In adolescent ballet dancers aged between 9 and 20, LBP
63 history has been associated with future musculoskeletal injury (Gamboa, Roberts, Maring, &
64 Fergus, 2008). Two previous LBP studies in dancers, both cross-sectional in design, have
65 observed higher rates of LBP in dancers than controls (McMeeken, et al., 2001), as well as
66 lifetime and point prevalence rates surpassing those seen in global adolescent and adult
67 populations (Swain, et al., 2017). These findings endorse LBP as a common health issue in
68 young, as well as professional dancers and, being well above that of the general population,
69 warranting more attention.

70 Importantly, there is considerable variability in how LBP manifests in individuals (Menezes
71 Costa, et al., 2012), and simple measures of prevalence can only provide a partial overview
72 of the problem. Little is currently known about the impact of LBP on dancers, as previous
73 studies have focussed on how much LBP is experienced, rather than the extent to which it
74 disrupts dance practice, or incites care-seeking and medication use. In addition, little is
75 known about the factors associated with LBP in dance, which limits the capacity to develop
76 targeted prevention strategies. This study had three aims: 1) to investigate, via prospective
77 cohort design, the prevalence of LBP in pre-professional and professional dancers, 2) to
78 determine the impact of LBP on dance participation, care-seeking and medication use, and
79 3) to determine factors associated with the experience of LBP.

80

81 **Methods**

82 A prospective cohort study was conducted over a nine-month period. Classical ballet
83 dancers from a pre-professional ballet school (n=95, aged 11-18), and a professional
84 nationally touring ballet company (n=29, age range unavailable) as well as contemporary
85 dancers from two pre-professional university dance programmes (n=77 and n=19, aged 17-
86 25) were invited to participate. Acceptance into each cohort is via an audition process,
87 ensuring a threshold of ability. Volunteers were eligible for inclusion in this study if they were
88 aged 12 years or more. No incentives were offered in return for participation. After providing
89 informed consent/assent, participants provided their email addresses to researchers to allow
90 distribution of online questionnaires. Ethics approval was granted by the X University Human
91 Research Ethics Committee.

92 Questionnaires were developed following review of the LBP, sport, and dance injury
93 literature. Participants received an initial online questionnaire (Qualtrics, USA) via email at
94 the commencement of the study, followed by a questionnaire sent at the end of each month
95 during the study period (Supplement 1). A single reminder email was sent to participants that

96 had not completed the questionnaire within seven days. All collected data were de-identified,
97 with participants creating their own login identification to allow for individual tracking.

98 The initial questionnaire collected demographic, dance and LBP history data, which have
99 been reported previously (Swain, et al., 2017). Subsequent questionnaires determined the
100 monthly prevalence of LBP, asking 'In the past month, have you had pain in your lower
101 back?' and were accompanied by a diagram of the posterior aspect of the body, highlighting
102 the region between the lower margin of the 12th ribs and the gluteal folds (Dionne, et al.,
103 2008). Participants who indicated they had experienced LBP were then asked whether the
104 episode was new (i.e. not present in the previous questionnaire), how intense the pain was
105 (a numeric scale of 0-10), and whether they were currently experiencing LBP. To determine
106 the impact of LBP, participants were asked the total amount, as well as percentage, of dance
107 activity they had to either modify or miss due to their pain, and whether they consulted a
108 health professional (yes or no) or used medication for their pain (yes or no). To provide a
109 measure of dance participation, all participants were asked for information about their dance
110 activity for the past month, including the type (class, rehearsal, or performance) and style
111 (classical, contemporary, or other), as well as the number and average duration of each
112 activity.

113 The prevalence of LBP (aim 1) was reported for the entire study period and for each month
114 of the study period, proportional to survey respondents. Episodes of LBP were defined as
115 'any LBP episode', which included all episodes of LBP, 'activity limiting LBP', which was an
116 episode of LBP that resulted in some form of missed or modified practice, and 'chronic LBP',
117 which occurred when participants indicated that they experienced three consecutive
118 episodes of LBP that were not new in a three-month period. Point prevalence was calculated
119 as the proportion of responders that indicated they were currently experiencing LBP at the
120 time of completing the questionnaire.

121 To determine the impact of LBP (aim 2), the proportion of LBP episodes requiring activity-
122 modification was calculated as a proportion of all LBP episodes. The proportion of the
123 sample that engaged in care-seeking or medication use was calculated as a proportion of
124 the entire sample as well a proportion of those that experienced LBP. Spearman correlations
125 were used to examine the relationship between reported pain-intensity of LBP episodes and
126 these outcomes. Significance was set at $p < 0.05$.

127 To determine factors associated with the experience of LBP (aim 3), exposure variables
128 including age, sex, body mass index (BMI), age started dancing, cohort type (dance school,
129 university, or company), and LBP history were described using frequencies and percentages
130 for categorical variables, and means (standard deviation) for continuous variables. Chi
131 square analyses and independent t-tests were used to examine univariate associations
132 between exposure measures and the presence or absence of LBP (i.e. i) 'any LBP episode',
133 ii) 'activity limiting LBP' and iii) 'chronic LBP'), followed by multivariate logistic regression to
134 adjust for confounders. Variables that showed significant association following univariate
135 analyses ($p < 0.25$) were entered into the multivariate model. A backward stepwise approach
136 was planned, whereby non-significant variables were removed from the model individually
137 ($p < 0.05$), and the reduced model compared with the initial model using likelihood ratio tests.
138 The resulting adjusted odds ratios (AORs) and associated 95% confidence intervals (CIs)
139 were reported. Multivariate models for any episode of LBP and chronic LBP were
140 underpowered and therefore, only the model for activity limiting LBP is presented. To assess
141 for a relationship between dance participation and LBP prevalence, Pearson (for parametric
142 data) and Spearman (for non-parametric data) correlations were performed between monthly
143 prevalence for all LBP episodes as well activity limiting LBP episodes and the mean number
144 of dance activities (class, rehearsal, and performance) as well as dance hours (number of
145 each activity type multiplied by the average duration of each corresponding activity) for each
146 month. All statistical analyses were performed using SPSS software for Windows (version
147 22.0, SPSS Inc., Chicago, IL, USA).

148

149 **Results**

150 Out of 220 individuals invited, 168 agreed to participate. The email addresses of three
151 individuals were invalid, necessitating their exclusion from the study. Two individuals
152 completed only the initial questionnaire, and were excluded from the final analysis. The initial
153 questionnaire as well as at least one subsequent monthly questionnaire was returned by 119
154 participants (54% of the sample invited, n=100 females). Participant demographic data is
155 presented in Table 1. Five hundred and eighty-five total monthly questionnaires were
156 collected throughout the course of the study. Twenty-two dancers completed all 10
157 questionnaires, 50 completed between five and nine, and 47 completed four or less. The
158 highest response rate was obtained for the first monthly questionnaire (62%) and the lowest
159 was recorded for the final questionnaire (22%). Sixty-three percent of monthly
160 questionnaires were completed within five minutes and 87% within 10 minutes.

161 Ninety-three (78%) participants reported at least one episode of LBP over the course of the
162 study, while 62 (52%) experienced an episode that resulted in some form of activity
163 limitation, and 29 (24%) experienced chronic LBP (Table 1). The point prevalence of LBP
164 was between 8 and 25%, with the highest rate observed in the third month (Figure 1).
165 Monthly prevalence (Figure 1) ranged from 19 to 58%, and 11 to 34% for all episodes of LBP
166 and activity limiting LBP, respectively.

167 For each LBP episode, 49% resulted in no modification to dance activities, 46% resulted in
168 up to half of dance activities being modified and the remaining 5% resulted in modification of
169 more than half of dance activities. Seventeen percent of LBP episodes resulted in some
170 portion of training being completely missed. A median pain intensity score of 4/10
171 (Interquartile range (IQR) = 3-6) was observed for all episodes of LBP and 5/10 (IQR = 3-7)
172 for episodes of activity limiting LBP. Of the 62 individuals that experienced activity limiting
173 LBP, 48% reported multiple episodes over the course of the study.

174 Thirty-four (29%) participants reported seeking health care for their LBP. Physiotherapists
175 were the most commonly seen professionals (seen by n=16), followed by, Pilates instructors
176 (n=5), chiropractors (n=5), and medical professionals (n=4). Medication use was reported by
177 25 (21%) participants, with 17 reporting the use of non-steroidal anti-inflammatories
178 (NSAIDs), and 14 reporting the use of paracetamol on at least one occasion. Other
179 medication reported included 'pain killers' or undisclosed (n=2). Of the medications reported,
180 one (Celebrex®, n=1) is available as prescription medication only. A median intensity score
181 of 5/10 (IQR = 4-7) was observed for LBP episodes that resulted in care-seeking and 6/10
182 (IQR = 5-7) for episodes resulting in medication use. There were significant, medium sized,
183 positive correlations between the intensity of each episode of LBP and care seeking ($r =$
184 $0.31, p < 0.01$), as well as medication use ($r = 0.38, p < 0.01$) each month.

185 The mean number of dance activities reported per month ranged from 35.5 to 60.2 (SD
186 range: 14.0-24.9). No significant relationship was identified between monthly dance activities
187 and the monthly prevalence of any LBP ($r = 0.29, p = 0.45$) or activity limiting LBP ($r = 0.38, p =$
188 0.32). The mean dance hours per month ranged between 49.9 to 85.3 (SD range: 21.4 to
189 44.4). No significant relationship was also identified between monthly dance hours and the
190 monthly prevalence of any LBP ($r = 0.48, p = 0.19$) or AL LBP ($r = 0.57, p = 0.11$). Large
191 variability was evident in the dance participation measures even when cohorts were
192 considered separately (standard deviations for dance hours ranging from 5.1 to 85.9 hours
193 per month), and when subgroups (e.g. year group) within cohorts were considered.

194 Exposure variables significantly associated with activity limiting LBP were entered into a
195 multivariate model (Table 2). These included history of LBP, age, age started dancing, and
196 cohort type (school, university, and company). After adjusting for confounding variables,
197 lifetime history was the only significant predictor of activity limiting LBP ($p = 0.01$).

198

199 Discussion

200 The purpose of this study was to determine the prevalence and impact of LBP in pre-
201 professional and professional dancers. In this cohort, LBP was common. The proportion of
202 dancers that experienced an episode of activity limiting LBP (52%) during the nine month
203 study period was above the yearly prevalence observed in the global adolescent
204 (34%)(Calvo-Munoz, et al., 2013) and adult populations (38%) (Hoy, et al., 2012), and within
205 the yearly prevalence ranges observed in a systematic review of Olympic sport disciplines
206 (24-66%) (Trompeter, Fett, & Platen, 2016). The monthly prevalence of activity limiting LBP
207 ranged from 11-34%, which is slightly higher than that seen in elite rowers (6-25%)
208 (Newlands, Reid, & Parmar, 2015); although, the mean (22%) was similar to the monthly
209 prevalence seen in the global population (23%) (Hoy, et al., 2012). Mean point prevalence
210 (17%) was above that seen in the global adolescent population (12%) (Calvo-Munoz, et al.,
211 2013), similar to the adult population (18%) (Hoy, et al., 2012), and at the lower end of the
212 range observed in Olympic sports (18-65%) (Trompeter, et al., 2016). However,
213 observations of Olympic sports included both current episodes and episodes in the last
214 seven days in their point prevalence definition, which potentially inflated the results.

215 Similar to patterns seen in other populations (Menezes Costa, et al., 2012), there was large
216 variation in how LBP was experienced by individuals. Of those that reported at least one
217 episode of pain, one third experienced no activity limitation and close to a third experienced
218 only a single episode, compared to a quarter that experienced chronic LBP. These results
219 highlight that disability as a result of LBP is not inevitable; however, nor is rapid recovery.
220 They also indicate a simple description of prevalence provides only a partial insight into the
221 problem.

222 The degree to which LBP incites care seeking can provide perspective on the impact of the
223 condition. Close to one third of the entire sample and half of those that experienced activity
224 limiting LBP reported seeking professional help. The moderate correlation between pain
225 intensity and care seeking seen here is consistent with non-athletic populations(Traeger, et
226 al., 2016), and indicates dancers are more likely to consult for episodes they perceive as

227 more severe. In addition, previous studies have identified a link between emotional distress
228 and consumption of health care for LBP, which emphasises the necessity for health
229 professionals who have expertise in managing dance conditions. Many dancers who
230 experienced LBP did not seek help, which is consistent with patterns in the general
231 population (Maher, et al., 2017), reinforces the proposal that many episodes of LBP recover
232 with minimal intervention (da, et al., 2012), and further highlights the variation in the
233 experience of LBP. Notably, the proportion that did pursue health care was lower than that
234 seen in Western Australian adolescents (O'Sullivan, Beales, Smith, & Straker, 2012). This
235 may suggest episodes in dance are less severe or that dancers are able to cope with some
236 level of pain (Jacobs, et al., 2017). It may also indicate reluctance amongst dancers to
237 acknowledge their pain, potentially as a product of cultural expectations, or through fear of
238 possible implications (Jacobs, et al., 2017; Turner & Wainwright, 2003).

239 More than one-fifth of the dancers in this sample reported the use of analgesic medication
240 for their LBP. Current consensus statements do support analgesic use as a component of
241 pain management in athletic populations (Hainline, et al., 2017) although, the effectiveness
242 of analgesics as a treatment for LBP is unclear (Machado, et al., 2017; Machado, et al.,
243 2015), and prolonged use can increase the likelihood of long-term sickness absence
244 (Sundstrup, Jakobsen, Thorsen, & Andersen, 2017). Dancers were more likely to use pain
245 medication for episodes that were more intense, or if they experienced activity limiting or
246 chronic LBP. While a complete understanding of the factors that influence the decision to
247 consume analgesics in this sample is not available, these results indicate that dancers do
248 want some form of pain relief. The use of over-the-counter medications may indicate a level
249 of self-management in the pain relieving process. If so, this would indicate the importance of
250 providing dancers with the appropriate education and resources to play an active role in pain
251 management (Sullivan & Vowles, 2017).

252 Consistent with previous studies, past history of LBP predicted the experience of activity
253 limiting LBP (Ferguson & Marras, 1997). This may reflect the recurrent nature of the LBP

254 experience (Maher, et al., 2017), or the influence of past experience on pain perception
255 (Tabor, Thacker, Moseley, & Kording, 2017). It is also possible that individuals who
256 experience LBP possess a range of underlying factors that increase their vulnerability to
257 LBP, which may persist across the lifespan (Hestbaek, Leboeuf-Yde, & Kyvik, 2006). As
258 such, a history of LBP should be included in dance health screening, and can be used to
259 identify at-risk populations who may be suitable for clinical intervention.

260 The current study was unable to find any overall association between the experience of LBP
261 and the participation data collected; although, these findings should be interpreted with
262 caution, as the self-reported participation data had a high degree of variability. In
263 epidemiological studies, documenting a link between physical exposure and LBP is difficult,
264 particularly given the complexities of spinal loading as well as the subjective nature of the
265 pain experience. This difficulty does not imply the lack of a causative relationship (Takala,
266 2010), as industry-based studies that have described exposure using precise quantitative
267 measures have shown much greater ability to predict loss in spine function related to pain
268 (Marras, et al., 2010), and cross sectional research in pre-professional dancers has
269 observed higher LBP prevalence in dancers with higher weekly dance hours (McMeeken, et
270 al., 2001). Nonetheless, it is also important to consider other factors that influence pain. For
271 instance, prior research with Irish dancers found the severity of pain and injury was more
272 closely linked to biopsychosocial factors than the mechanical measures collected (Cahalan,
273 et al., 2016).

274 Monthly LBP, activity limiting LBP, and point prevalence steadily declined over the course of
275 the study. There are several possible explanations for this finding. That LBP prevalence was
276 lowest in the final month may partially reflect a seasonal effect. At this time, the two
277 university cohorts had finished their final performances, while the school had completed its
278 major performance three months earlier and the final term was close to conclusion. The
279 findings may also indicate that an improvement in both fitness and movement ability
280 occurred during the study period, increasing the capacity for dancers to manage the physical

281 demands placed upon them. Alternatively, it is possible that continued participation in the
282 project led to an upward shift in the individual threshold for reporting pain; however, the
283 opposite may also be true, and ongoing participation may be just as likely to increase one's
284 awareness of LBP and its impact. The attrition rate should be considered as a potential
285 factor that contributed to the decline in prevalence, yet, dropout occurred in both individuals
286 who experienced and did not experience pain, and a prior surveillance study found a decline
287 in injury rate was not associated with a change in the response rate (Ekegren, Gabbe, &
288 Finch, 2014).

289 The major limitation of this study was the response and attrition rate. To counter the
290 expected attrition, we used multiple cohorts and communicated the purpose to each
291 individual in person, although we were unable to offer any significant incentive. Self-report
292 based surveillance studies that have achieved higher participation have often featured a
293 collection of highly disciplined elite athletes (Clarsen, et al., 2014; Newlands, et al., 2015),
294 more persistent and personalised follow up that may be linked to medical care (Clarsen, et
295 al., 2014; Ekegren, Gabbe, et al., 2014), or researchers with a status that participants may
296 admire (Cahalan, et al., 2016). The monthly questionnaire was designed to present minimal
297 burden for participants; however, it was more complex than the tool used by (Clarsen, et al.,
298 2014) and it is possible this contributed to the attrition. Reassuringly, available evidence
299 does not suggest that a lower response rate in epidemiology studies automatically implies
300 low validity or the presence of substantial bias (Galea & Tracy, 2007; Morton, Bandara,
301 Robinson, & Carr, 2012), although the exact age range and sex distribution for each cohort
302 was not attainable, and application to the wider dance community may not be automatically
303 assumed.

304 While the questionnaire used was not formally validated or tested for reliability, the initial and
305 monthly questionnaire were discussed with dance education and health professionals from
306 more than one cohort, and reviewed by a dance science professional outside the research
307 team as well as a group of senior ballet school students. The questionnaires were confirmed

308 to have face validity. The definition of LBP, which was accompanied by a diagram, is
309 consistent with the standardised definition of LBP for use in prevalence studies (Dionne, et
310 al., 2008) and a meta-analysis of LBP prevalence studies in children and adolescents
311 indicated that one month and point period prevalence's are less affected by publication bias
312 (Calvo-Munoz, et al., 2013), which supports monthly distribution of questionnaires. The
313 dance participation data component of the questionnaire was modelled on the tool used by
314 Newlands et al., (2015), which although not validated, did successfully demonstrate a
315 relationship between monthly training load and LBP in junior and senior elite rowers. This
316 was modified so that the participation data matched the dance exposure categories (class,
317 rehearsal, performance) described by an IADMS standard measures consensus statement
318 (Liederbach, Hagins, Gamboa, & Welsh, 2012).

319 Importantly, LBP is not a homogenous condition. While this study describes the prevalence
320 and impact of LBP in pre-professional and professional dancers, it is likely that the
321 mechanisms responsible for LBP development within the sample are vast. For instance,
322 repetitive application of complex loads to the spine, combined with aspects of growth and
323 maturation, may predispose young dancers to specific spine injuries (Adams, 2004;
324 Bergeron, et al., 2015). Similarly, the physical, social, and personal contexts would differ
325 greatly between a university level contemporary dancer and a professional ballet dancer,
326 and these may influence pain.

327 Clinically, as a history of LBP was identified as a predisposing factor to the experience of
328 activity limiting LBP, reducing the incidence of first time LBP in young dancers could have
329 long term health benefits. Furthermore, as dancers appear to be a population at risk, efforts
330 to provide them with the skills and resources to play an active role in responding to pain
331 would be appropriate. Future research would do well to investigate factors that contribute to
332 LBP in dance, as well as dancer's knowledge of available pain management.

333

334 Conclusion

335 Results from this study support the assertion that pre-professional and professional dancers
336 are vulnerable to experiencing LBP and there is suggestion of a seasonal effect in this
337 population. Low back pain history increases future risk, and for a significant portion of
338 dancers, pain is ongoing, interferes with dance participation and provokes care-seeking and
339 medication use. Accordingly, dance students and professionals need access to healthcare
340 professionals with expertise in the management of LBP and its consequences. Artistic and
341 education staff should be sensitive to the complexities of pain, and its interaction with dance
342 participation.

343

344 Conflicts of interest

345 None

346

347 **References**

- 348 Australian Bureau of Statistics. Children's Participation in Cultural and Leisure Activities,
349 Australia. 2012. Available at: <http://www.abs.gov.au/ausstats/abs@.nsf/mf/4901.0>.
350 Accessed 15 February 2017.
- 351 Adams, M. A. (2004). Biomechanics of back pain. *Acupunct Med*, *22*, 178-188.
- 352 Allen, N., Nevill, A., Brooks, J., Koutedakis, Y., & Wyon, M. (2012). Ballet injuries: injury
353 incidence and severity over 1 year. *J Orthop Sports Phys Ther*, *42*, 781-790.
- 354 Bergeron, M. F., Mountjoy, M., Armstrong, N., Chia, M., Côté, J., Emery, C. A., Faigenbaum,
355 A., Hall, G., Kriemler, S., Léglise, M., Malina, R. M., Pensgaard, A. M., Sanchez, A.,
356 Soligard, T., Sundgot-Borgen, J., van Mechelen, W., Weissensteiner, J. R., &
357 Engebretsen, L. (2015). International Olympic Committee consensus statement on
358 youth athletic development. *British Journal of Sports Medicine*, *49*, 843-851.
- 359 Cahalan, R., O'Sullivan, P., Purtill, H., Bargary, N., Ni Bhriain, O., & O'Sullivan, K. (2016).
360 Inability to perform because of pain/injury in elite adult Irish dance: A prospective
361 investigation of contributing factors. *Scand J Med Sci Sports*, *26*, 694-702.
- 362 Calvo-Munoz, I., Gomez-Conesa, A., & Sanchez-Meca, J. (2013). Prevalence of low back
363 pain in children and adolescents: a meta-analysis. *BMC Pediatr*, *13*, 14.
- 364 Clarsen, B., Ronsén, O., Myklebust, G., Florenes, T. W., & Bahr, R. (2014). The Oslo Sports
365 Trauma Research Center questionnaire on health problems: a new approach to
366 prospective monitoring of illness and injury in elite athletes. *Br J Sports Med*, *48*, 754-
367 760.
- 368 Crookshanks, D., & Trotter, H. (1999). *Safe dance III: Report 1999: A report on the*
369 *occurrence of injury in the Australian professional dance population*: Australian
370 Dance Council, Ausdance.
- 371 Dionne, C. E., Dunn, K. M., Croft, P. R., Nachemson, A. L., Buchbinder, R., Walker, B. F.,
372 Wyatt, M., Cassidy, J. D., Rossignol, M., Leboeuf-Yde, C., Hartvigsen, J., Leino-
373 Arjas, P., Latza, U., Reis, S., Gil Del Real, M. T., Kovacs, F. M., Oberg, B.,

- 374 Cedraschi, C., Bouter, L. M., Koes, B. W., Picavet, H. S., van Tulder, M. W., Burton,
375 K., Foster, N. E., Macfarlane, G. J., Thomas, E., Underwood, M., Waddell, G.,
376 Shekelle, P., Volinn, E., & Von Korff, M. (2008). A consensus approach toward the
377 standardization of back pain definitions for use in prevalence studies. *Spine (Phila Pa*
378 *1976)*, *33*, 95-103.
- 379 Ekegren, C. L., Gabbe, B. J., & Finch, C. F. (2014). Injury reporting via SMS text messaging
380 in community sport. *Inj Prev*, *20*, 266-271.
- 381 Ekegren, C. L., Quested, R., & Brodrick, A. (2014). Injuries in pre-professional ballet
382 dancers: Incidence, characteristics and consequences. *J Sci Med Sport*, *17*, 271-
383 275.
- 384 Ferguson, S. A., & Marras, W. S. (1997). A literature review of low back disorder surveillance
385 measures and risk factors. *Clin Biomech (Bristol, Avon)*, *12*, 211-226.
- 386 Galea, S., & Tracy, M. (2007). Participation rates in epidemiologic studies. *Ann Epidemiol*,
387 *17*, 643-653.
- 388 Gamboa, J. M., Roberts, L. A., Maring, J., & Fergus, A. (2008). Injury patterns in elite
389 preprofessional ballet dancers and the utility of screening programs to identify risk
390 characteristics. *J Orthop Sports Phys Ther*, *38*, 126-136.
- 391 Hainline, B., Derman, W., Vernec, A., Budgett, R., Deie, M., Dvořák, J., Harle, C., Herring, S.
392 A., McNamee, M., Meeuwisse, W., Lorimer Moseley, G., Omololu, B., Orchard, J.,
393 Pipe, A., Pluim, B. M., Ræder, J., Siebert, C., Stewart, M., Stuart, M., Turner, J. A.,
394 Ware, M., Zideman, D., & Engebretsen, L. (2017). International Olympic Committee
395 consensus statement on pain management in elite athletes. *British Journal of Sports*
396 *Medicine*, *51*, 1245-1258.
- 397 Hestbaek, L., Leboeuf-Yde, C., & Kyvik, K. O. (2006). Is comorbidity in adolescence a
398 predictor for adult low back pain? A prospective study of a young population. *BMC*
399 *Musculoskelet Disord*, *7*, 29.

- 400 Hoy, D., Bain, C., Williams, G., March, L., Brooks, P., Blyth, F., Woolf, A., Vos, T., &
401 Buchbinder, R. (2012). A systematic review of the global prevalence of low back
402 pain. *Arthritis Rheum*, *64*, 2028-2037.
- 403 Jacobs, C. L., Cassidy, J. D., Cote, P., Boyle, E., Ramel, E., Ammendolia, C., Hartvigsen, J.,
404 & Schwartz, I. (2017). Musculoskeletal Injury in Professional Dancers: Prevalence
405 and Associated Factors: An International Cross-Sectional Study. *Clin J Sport Med*,
406 *27*, 153-160.
- 407 Liederbach, M., Hagins, M., Gamboa, J. M., & Welsh, T. M. (2012). Assessing and reporting
408 dancer capacities, risk factors, and injuries: recommendations from the IADMS
409 standard measures consensus initiative. *Journal of Dance Medicine & Science*, *16*.
- 410 Machado, G. C., Maher, C. G., Ferreira, P. H., Day, R. O., Pinheiro, M. B., & Ferreira, M. L.
411 (2017). Non-steroidal anti-inflammatory drugs for spinal pain: a systematic review
412 and meta-analysis. *Ann Rheum Dis*.
- 413 Machado, G. C., Maher, C. G., Ferreira, P. H., Pinheiro, M. B., Lin, C. W., Day, R. O.,
414 McLachlan, A. J., & Ferreira, M. L. (2015). Efficacy and safety of paracetamol for
415 spinal pain and osteoarthritis: systematic review and meta-analysis of randomised
416 placebo controlled trials. *Bmj*, *350*, h1225.
- 417 Maher, C., Underwood, M., & Buchbinder, R. (2017). Non-specific low back pain. *Lancet*,
418 *389*, 736-747.
- 419 Marras, W. S., Lavender, S. A., Ferguson, S. A., Splittstoesser, R. E., & Yang, G. (2010).
420 Quantitative dynamic measures of physical exposure predict low back functional
421 impairment. *Spine (Phila Pa 1976)*, *35*, 914-923.
- 422 Menezes Costa, L. D.C., Maher, C. G., Hancock, M. J., McAuley, J. H., Herbert, R. D., &
423 Costa, L. O. (2012). The prognosis of acute and persistent low-back pain: a meta-
424 analysis. *CMAJ*, *184*, E613-624.
- 425 McMeeken, J., Tully, E., Stillman, B., Nattrass, C., Bygott, I. L., & Story, I. (2001). The
426 experience of back pain in young Australians. *Man Ther*, *6*, 213-220.

- 427 Morton, S. M., Bandara, D. K., Robinson, E. M., & Carr, P. E. (2012). In the 21st Century,
428 what is an acceptable response rate? *Aust NZ J Public Health*, 36, 106-108.
- 429 Newlands, C., Reid, D., & Parmar, P. (2015). The prevalence, incidence and severity of low
430 back pain among international-level rowers. *Br J Sports Med*, 49, 951-956.
- 431 O'Sullivan, P. B., Beales, D. J., Smith, A. J., & Straker, L. M. (2012). Low back pain in 17
432 year olds has substantial impact and represents an important public health disorder:
433 a cross-sectional study. *BMC Public Health*, 12, 100.
- 434 Sullivan, M. D., & Vowles, K. E. (2017). Patient action: as means and end for chronic pain
435 care. *Pain*, 158, 1405-1407.
- 436 Sundstrup, E., Jakobsen, M. D., Thorsen, S. V., & Andersen, L. L. (2017). Regular use of
437 medication for musculoskeletal pain and risk of long-term sickness absence: A
438 prospective cohort study among the general working population. *Eur J Pain*, 21, 366-
439 373.
- 440 Swain, C. T., Bradshaw, E. J., Whyte, D. G., & Ekegren, C. L. (2017). Life history and point
441 prevalence of low back pain in pre-professional and professional dancers. *Phys Ther*
442 *Sport*, 25, 34-38.
- 443 Tabor, A., Thacker, M. A., Moseley, G. L., & Kording, K. P. (2017). Pain: A Statistical
444 Account. *PLoS Comput Biol*, 13, e1005142.
- 445 Takala, E. P. (2010). Lack of "statistically significant" association does not exclude causality.
446 *Spine J*, 10, 944; author reply 944-945.
- 447 Traeger, A. C., Hubscher, M., Henschke, N., Williams, C. M., Maher, C. G., Moseley, G. L.,
448 Lee, H., & McAuley, J. H. (2016). Emotional distress drives health services overuse
449 in patients with acute low back pain: a longitudinal observational study. *Eur Spine J*,
450 25, 2767-2773.
- 451 Trompeter, K., Fett, D., & Platen, P. (2016). Prevalence of Back Pain in Sports: A Systematic
452 Review of the Literature. *Sports Med*.
- 453 Turner, B. S., & Wainwright, S. P. (2003). Corps de ballet: the case of the injured ballet
454 dancer. *Sociol Health Illn*, 25, 269-288.

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Table I: Descriptive data. Results are reported as mean (standard deviation) for continuous variables and frequencies (percentage) for categorical variables.

	Entire cohort		Any LBP		Activity limiting LBP		Chronic LBP	
	Male (n=19)	Female (n=100)	Yes 93 (78)	No 26 (22)	Yes 62 (52)	No 57 (48)	Yes 29 (24)	No 90 (76)
Male n (%)	15 (79)	4 (21)	8 (42)	11 (58)	6 (32)	13 (68)
Female n (%)	78 (78)	22 (22)	54 (54)	46 (46)	23 (23)	77 (77)
Age (yrs) [†]	17.1 (3.7)	17.9 (2.7)	18.0 (2.8)	16.8 (2.9)	18.3 (2.8)	17.1 (2.9)	18.2 (2.8)	17.6 (2.9)
Height (cm) [‡]	175.2 (9.8)	165.1 (7.6)	167.7 (8.6)	163.4 (9.2)	167.6 (8.8)	166.1 (8.9)	168.0 (8.6)	166.4 (8.9)
Body mass (kg) [§]	65.1 (13.3)	54.0 (8.6)	56.9 (10.5)	52.0 (9.3)	56.8 (9.8)	54.9 (11.1)	58.3 (11.2)	54.9 (9.9)
BMI (kg/m ²) [¶]	21.0 (3.1)	19.7 (2.4)	20.1 (2.7)	19.3 (2.0)	20.2(2.5)	19.7 (2.6)	20.6 (2.9)	20.6 (2.9)
Age started dance (yrs) [#]	9.3 (4.8)	7.4 (4.6)	7.6 (4.9)	8.0 (4.1)	8.3 (5.2)	7.1 (4.0)	8.2 (5.1)	7.5 (4.6)
Years dancing [#]	7.8 (6.2)	10.4 (5.0)	10.4 (5.3)	8.4 (5.3)	10.0 (5.4)	9.9 (5.2)	10.0 (5.7)	10.0 (5.2)
Cohort type								
School n (%)	10 (53)	27 (27)	24 (65)	13 (35)	13 (35)	24 (65)	7 (19)	30 (81)
University n (%)	8 (42)	59 (59)	57 (85)	10 (15)	37 (55)	30 (45)	18 (27)	49 (73)
Company n (%)	1 (5)	14 (14)	12 (80)	3 (20)	12 (80)	3 (20)	4 (27)	11 (73)
History of LBP n (%) [†]	15 (79)	65 (74)	70 (82)	10 (46)	50 (86)	30 (61)	28 (96)	52 (66)
Used healthcare n (%)	5 (26)	29 (29)	34 (37)	0	31 (50)	3 (5)	13 (45)	21 (23)
Used medication n (%)	3 (16)	22 (22)	25 (27)	0	20 (32)	5 (9)	12 (41)	13 (14)

[†]Data missing for n = 11 cases

[‡]Data missing for n = 20 cases

[§]Data missing for n = 21 cases

[¶]Data missing for n = 23 cases

#Data missing for n = 14 cases

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Table 2: Univariate and multivariate associations with activity limiting low back pain

Population descriptor	Mean (SD)/ n (%)	Univariate analysis	Multivariable analysis	
		p	AOR (95% CI)	p
Age (yrs) [†]	18.3 (2.8)	0.05	0.99 (0.76, 1.29)	0.93
Age started dancing (yrs) [‡]	8.3 (5.2)	0.20	1.04 (0.95, 1.14)	0.40
Cohort Type		0.01*		
School n (%)	13 (35)		1.00 (ref)	
University n (%)	37 (55)		0.14 (0.01, 1.33)	0.09
Company n (%)	12 (80)		0.34 (0.07, 1.59)	0.17
History of LBP n (%) ^a	50 (86)	<0.01*	3.98 (1.44, 11.00)	<0.01*

AOR, adjusted odds ratio

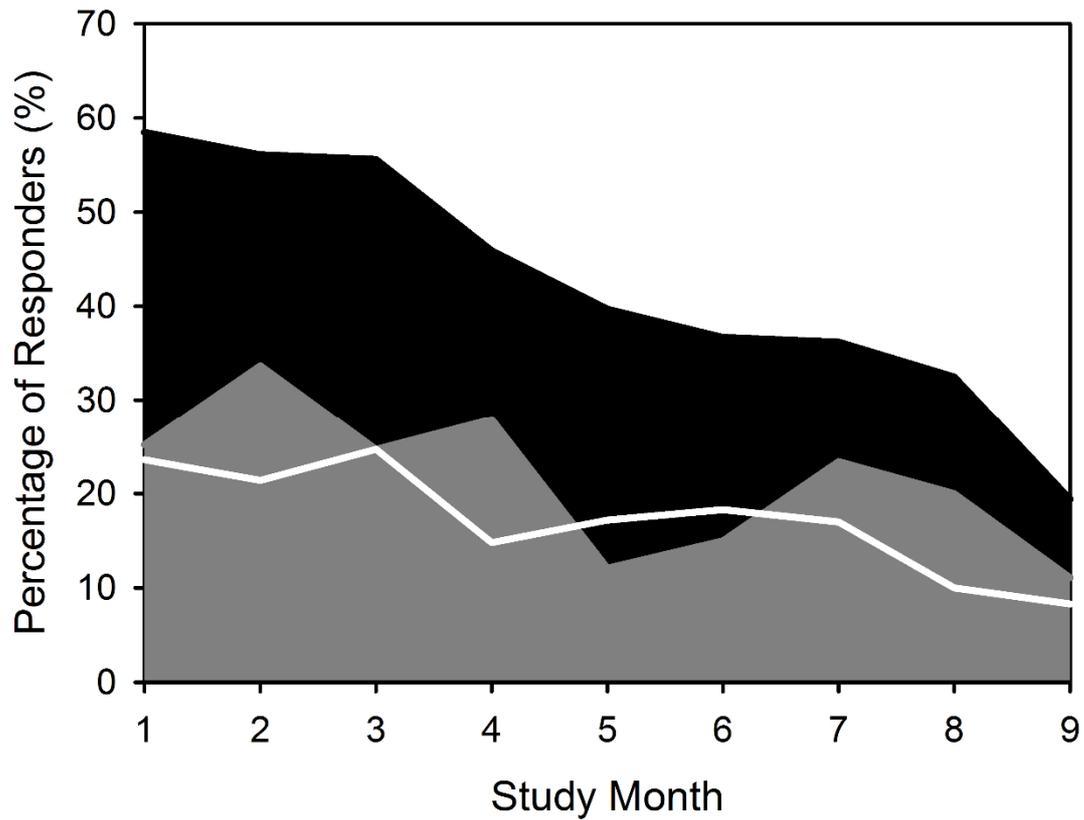
[†]Data missing for n = 11 cases

[‡]Data missing for n = 14 cases

* p< 0.05

Fig 1. Monthly experience of all episodes of LBP, activity limiting LBP, and current LBP.

The black area represents all episodes of LBP, the grey area represents episodes of activity limiting LBP and the white line represents the point prevalence of LBP.



Highlights

- Prevalence of LBP in dancers is similar to those reported in other elite sport
- A high degree of variation exists between LBP symptoms and impact on participation
- Past history of LBP increases future risk

ETHICS STATEMENT: The prevalence and impact of low back pain in pre-professional and professional dancers: a prospective study

The authors confirm that the participants rights and confidentiality have been well protected in all aspects and they consented to the study described in the work. All relevant ethical safeguards have been met in relation to participant protection. Approval from the appropriate ethics committees have been obtained as indicated in the manuscript.

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