Injury incidence and severity in pre-professional Musical Theatre Dancers: a 5-year prospective study

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Abstract

Dance injury research has mainly focused on ballet and modern dance with little data on musical theatre dancers. The purpose was to assess the incidence and severity of injuries in a musical theatre dance college over a 5-year period; 198 pre-professional musical theatre dancers (3 cohorts on a 3-year training course) volunteered for the study; 21 students left the course over the study period. Injury aetiology data were collected by an in-house physiotherapy team. Differences between academic year and sex were analysed using a Poisson distribution model; significant difference was set at $p \leq 0.05$. In total 913 injuries were recorded, more injuries occurred in academic year 1 than year 2 and 3. Overall injury incidence was 1.46 injuries per 1000 hours (95%CI 1.34, 1.56); incidence significantly decreased between year 1, 2 and 3 ($p<0.05$). There was no significant sex difference for incidence or severity. Most injuries were classified as overuse (71% female, 67% male). Pre-professional musical theatre dancers report a high proportion of lower limb and overuse injuries that is comparable to other dance genres. Unlike other studies on pre-professional
dancers; injury incidence and severity decreased with academic year, even though workload increased across the course.

**Keywords:** aetiology; injury rate; vocational training; overuse injuries; dance

**Introduction**

Musical theatre is a form of theatrical performance that combines singing, spoken dialogue, acting and dance. The performer needs to be highly skilled in many genres of dance, but equally skilled in acting and singing. Musical theatre dancers perform complex routines, requiring a high level of athletic ability, often whilst singing and always in character [1], and are therefore at risk of injury due to the extreme physical demands placed upon their bodies [2].

Accurate research investigating injury incidence and severity within dance is challenging due to methodological inconsistencies in published epidemiological studies [3]. In addition, much of the research to date has been conducted in ballet, contemporary and modern dance, with very little in the way of information on the musical theatre. There are two published studies reporting injury occurrence in musical theatre. Evans et al[4] retrospectively surveyed 313 Broadway performers from 23 companies using a self-report, self-defined injury questionnaire for the current production they were in. The survey reported a mean injury rate of 1.08 per performer for all the cast; specifically females sustained 1.4 ±1.3 injuries per dancer and males 1.1 ±1.4 injuries per dancer. Time missed due to injury was reported in weeks with females 0.9 ±2.7 and males 0.4 ±1.0. Through odds ratio analysis the factors that increased the risk of injury for dancers was being female (2.4), being a professional longer (3.8), having a previous injury (2.5), being cast for a physically demanding role (3.0), and performing on a raked stage (3.0). In a further retrospective survey study on West End
performers in 8 musical theatre productions, including the highly physical Starlight Express musical, Evans et al[2] reported that professional performers had an injury rate of 2.95 injuries per performer with 81% of performers injured during production. In the only known study that incorporated diagnoses by medical practitioners, Bronner & Brownstein[5], reported injury incidence and aetiology of dancers in a short run of the musical, The Red Shoes, on Broadway. In this 7-week run, there were 9 major injuries resulting in 82 missed and 35 partial performances, and 3 minor injuries resulting in 22 partial performances. Forty percent of dancers sustained an injury and in any given performance, 4.9% were out with a major injury, and 3.4% danced partial performances. Injuries recorded were only lower limb, with the foot and ankle accounting for 50% of the injuries. More recently James and Lazarczuk[6] performed another retrospective injury survey on 47 West End performers who sustained a total of 60 injuries (any incident resulting in physical damage to the person). Fifty percent of the injuries were lower limb and muscle strain was the most common type (37%); 63% of injuries did not result in time off and only 12% required the dancer to miss 1 or more weeks. The variation in data collection methods in the above studies highlight the need for consensus in data collection in dance in order to improve the quality of evidence in dance injury literature and to enable comparisons to be made to enable healthcare improvements. The aim of this study was to assess the incidence and severity of injuries in a musical theatre dance college over a 5-year period. Specific objectives were to report the site, incidence, severity and aetiology of the injuries; whether they were traumatic or overuse; and the episode of injury (first occurrence, exacerbation, or recurrence); and sex and year group differences.

Materials and Methods
Musical theatre dancers in an independent further education college for performing arts based in the UK were studied prospectively over 5 academic years (September 2013 – July 2018). The college has an 85% 5-year average profession employment rate. All dancers were enrolled full-time on a 3-year Musical Theatre (Dance) or Professional Musical Theatre course. Three cohorts were monitored between September 2013 and July 2018; 198 students (M=42, F=156) enrolled over the 3 cohorts. There was a 10% (n=21) drop-out over the 3-year course due to personal reasons (financial and or change in career goals), with males having a slightly higher percentage drop than females (14% vs. 10%); there were no drop-outs due to medical causes. At point of entry into the course and at the start of each year, students signed informed consent that their anonymised injury data could be used for research purposes and ethical approval was provided by the second author’s institution, University of Wolverhampton Ethics Committee (0918MW3UOW). The ethical approval was recognised and approved by the primary institution where the data were being collected.

On entry female dancers were 18 ± 1.2 years, 164.6 ± 5.6 cm height, 58.2 ± 7.0 kg body mass, and 21.4 ± 2.1 kg/m² BMI; male dancers were 18 ± 1.2 years, 179.1 ± 6.1 cm height, 69.4 ± 7.9 kg body mass, and 21.6 ± 2.3 kg/m² BMI. All dancers were split into year groups (years 1, 2 & 3). Year 1 and 2 focus on technique and “in-house” performances; whilst year 3 focuses on the students’ preparation for the profession with 4-5 productions. Dancers trained 5 days a week over three 12-week periods that included a rest week at week 6. Formal college holiday times included 3.5 weeks at Christmas and Easter and 9 weeks during the summer. The dancers all had access to the in-house, on-site expert dance-physiotherapy team, consisting of three chartered physiotherapists, that were available 5 days a week.
The average number of dance hours per week across all 3 year-groups were 33.2 hours for male dancers and 31.6 hours for female dancers. Classes included daily ballet and jazz in addition to tap, contemporary, commercial dance, musical theatre dance, gymnastics and heels-based classes. These hours did not include timetabled non-dance classes such as voice, acting, singing, non-dance based musical theatre or academic classes but, included compulsory, student-led, early morning warm-up sessions.

Injuries were recorded by the in-house physiotherapists on a standardised injury-assessment form. An injury was defined as an episode of pain with an underlying aetiology as diagnosed by the physiotherapy team. In contrast to previously used definitions of injury that require at least 24 hours of dance non-participation for an injury to be recorded[7], we recorded an injury based on reported pain and aetiology, even if a dancer was able to participate in some aspects of their dance training.

Injury severity, for time-loss injuries, was defined by the number of days a dancer took to return to full fitness defined as the ability to take a full part in dance activities[7]. Injury diagnosis was recorded using the Orchard Sports Injury Classification system (version 9). During analysis, the injuries were grouped into body regions[7, 8]. A recurrent injury was defined as an injury of the same type and location as the first episode, occurring at least 2 months after a dancer’s return to full participation. An exacerbation was defined as a worsening of the state of a non-recovered complaint. All other injuries were classified as first-episode injuries. Injuries were further classified as nature (intrinsic or extrinsic) and traumatic or overuse and activity[7, 9], the latter based on the dancer’s recall of the activity they were doing. Individual dance exposure was recorded and calculated using detailed timetables of each term's scheduled dance activities for both males and females in each year group and time-loss due to injury.
Injury rate for each dancer was calculated as the number of injuries per year. The mean and 95% confidence interval (CI) were calculated for each dependent variable, with the exception of injury severity where the median value has been reported due to a small number of long-term injuries affecting the mean. The injury rate was analysed assuming a Poisson distribution (Injuries~Poisson[π_i]) using the MLwin software (Version 2.22; Centre for Multilevel Modelling, University of Bristol, United Kingdom). Because injury rates are counts, the number of injuries was analysed using a log link (var[injury|π_i]=π_i). For the current injury data, the effect of academic year on the number of injuries was assessed using the following model:

\[ \log(\pi_i) = \beta_0 + \beta_1 F_i + \beta_2 year2_i + \beta_3 year3_i \]

Where the cons is the constant intercept parameter, \( \beta_1, \beta_2 \) and \( \beta_3 \) the estimated difference due to academic years 1, 2 and 3 for males and \( F \) is the female constant.

A similar equation was used to analyse injury incidence, traumatic and overuse injuries per 1000 hours.

\[ \log(\pi_i) = \beta_0 + \beta_3 F_i + \beta_2 year2_i + \beta_3 year3_i + \beta_4 Hrsper1000_i \]

**Results**

Over the three 3-year cohort periods, 913 injuries were reported in total; 411 injuries in year 1, 317 in year 2 and 185 in year 3 (Table 1). Across the data collection period 58% of male dancers and 62% of female dancers reported being injured; the percentage of the cohort that were injured decreased across the 3-year period (year 1: M=75%, F=79%; year 2: M=59%, F=61%; year 3: M=58%, F=43%). With respect to injury rate, the software estimated the decline in injury rate for year 2 to be -0.165 (SE=0.075, p<0.05), for year 3 to be -0.594
(SE=0.094, p<0.05) and the effect of sex was -0.137 (SE=0.079) for females. The software reported “exposure hours” had little effect beyond that reported by “injury rate” as all years were exposed to approximately 1000 hours training a year (Year 1: 954 hrs; Year 2: 1098 hrs; Year 3: 1148 hrs). Table 1 shows the mean injuries per dancer and injury incidence by sex for all 3 years of the course.

Table 1: Total injuries, mean injury rate per dancer, mean injury incidence per 1000 hours exposure and median injury severity across the 3-years

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sex</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total injuries</td>
<td>Female</td>
<td>312</td>
<td>243</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>97</td>
<td>74</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>409</td>
<td>317</td>
<td>185</td>
</tr>
<tr>
<td>Injuries/1000hrs per year (95% CI)</td>
<td>Female</td>
<td>1.89 (1.71, 2.54)</td>
<td>1.39 (1.19, 1.62)</td>
<td>0.86 (0.72, 1.04)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>2.19 (1.89, 2.54)</td>
<td>1.61 (1.39, 1.87)</td>
<td>1.01 (1.12, 1.53)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1.94 (1.77, 2.14)</td>
<td>1.44 (1.24, 1.67)</td>
<td>0.89 (0.86, 1.17)</td>
</tr>
<tr>
<td>Injuries per dancer per year (95% CI)</td>
<td>Female</td>
<td>1.81 (1.63, 2.00)</td>
<td>1.53 (1.32, 1.77)</td>
<td>0.99 (0.83, 1.18)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>2.07 (1.78, 2.42)</td>
<td>1.76 (1.51, 2.05)</td>
<td>1.14 (0.98, 1.34)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1.86 (1.645, 1.98)</td>
<td>1.58 (1.32, 1.78)</td>
<td>1.03 (0.84, 1.19)</td>
</tr>
<tr>
<td>Severity - Days off [Range]</td>
<td>Female</td>
<td>7 [1-365]</td>
<td>10 [1-270]</td>
<td>7 [1-56]</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7 [1-180]</td>
<td>10 [1-270]</td>
<td>7 [1-56]</td>
</tr>
</tbody>
</table>

Overuse injuries accounted for 71% of injuries in females and 67% of injuries in males; Poisson distribution analysis of overuse and traumatic injury rate reported a significant decrease (p<0.05) in overuse injuries across the years but no sex effect. Males reported a non-significant year interaction for traumatic injury rate with a slight decrease between years 1 and 3, whilst females’ rates remained constant across the year groups.
Injury severity, defined as days absent due to injury, were similar across the years (Table 1), though days off due to traumatic injury were significantly more than those lost due to overuse injuries (p<0.05) (Table 2).
<table>
<thead>
<tr>
<th>Year</th>
<th>Total cohort</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Injuries</td>
<td>Injury rate (95% CI)</td>
<td>Median Severity (Days)</td>
</tr>
<tr>
<td>Overuse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>300</td>
<td>1.36 (1.21, 1.52)</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>221</td>
<td>1.11 (0.93, 1.32)</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>110</td>
<td>0.61 (0.49, 0.76)</td>
<td>7</td>
</tr>
<tr>
<td>Traumatic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>109</td>
<td>0.49 (0.41, 0.59)</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>96</td>
<td>0.47 (0.36, 0.62)</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>0.42 (0.31, 0.56)</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3: Number of injuries for body regions between the year groups

<table>
<thead>
<tr>
<th>Injury frequency</th>
<th>Foot</th>
<th>Ankle</th>
<th>Lower Leg</th>
<th>Knee</th>
<th>Upper Leg</th>
<th>Pelvis /Hip</th>
<th>Lumbar</th>
<th>Thoracic /Ribs</th>
<th>Shoulder</th>
<th>Arm /Hand</th>
<th>Head /Neck</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1 1</td>
<td>51</td>
<td>44</td>
<td>62</td>
<td>73</td>
<td>54</td>
<td>39</td>
<td>35</td>
<td>19</td>
<td>17</td>
<td>7</td>
<td>10</td>
<td>411</td>
</tr>
<tr>
<td>Year 2 1</td>
<td>29</td>
<td>32</td>
<td>47</td>
<td>51</td>
<td>42</td>
<td>29</td>
<td>24</td>
<td>20</td>
<td>23</td>
<td>4</td>
<td>16</td>
<td>317</td>
</tr>
<tr>
<td>Year 3 1</td>
<td>11</td>
<td>19</td>
<td>16</td>
<td>15</td>
<td>30</td>
<td>23</td>
<td>26</td>
<td>18</td>
<td>17</td>
<td>4</td>
<td>17</td>
<td>185</td>
</tr>
<tr>
<td>Total Injuries</td>
<td>91</td>
<td>95</td>
<td>125</td>
<td>139</td>
<td>126</td>
<td>91</td>
<td>85</td>
<td>57</td>
<td>57</td>
<td>15</td>
<td>43</td>
<td>913</td>
</tr>
</tbody>
</table>
Injuries related to intrinsic factors accounted for the majority of injuries (95% F=95%, M=97%). Extrinsic factors (5%; F=4.9, M=3%) were mainly related to footwear and venue; the former included the diversity of footwear MT dancers need to perform in (tap shoes, high heels, jazz shoes, etc) and the latter, the different venues particularly when performing or rehearsing away from the school. Both female and male dancers experienced a higher incidence of first episode injuries (female, 67%; male, 71%), than recurrent injuries (female, 31%; male 27.5%) and exacerbation injuries (female 2%; male 2%).

When comparing the three dance related activities dancers experienced the most injuries during class (23%; F=24%, M=22%) followed by rehearsal (5%; F=5%, M=7%) and finally performance (3%; F=3%, M=4%). Sixty-seven percent of the injuries had an unknown cause and 1% were non-dance related injuries. There was no significant difference in days off due to injury between the three dance activities.

The majority of injuries sustained were to the knee, lower leg and upper leg regions for both males and females across the year groups (Table 3). Thigh muscle spasm/strain/tear and knee joint/ligament derangement were the most common injury groupings overall (Table 4) with mean days off between 11-19. Only stress fractures (including tibia and metatarsal) resulted in substantial days off; though ankle instability, ankle impingement and knee joint/ligament derangement resulted in on average 17-26 days off and had a higher incidence. Injury groupings related to the ankle in male dancers had higher number of days lost to dance than any other injury except the stress fractures (Table 4).
Table 4: Injury rate and severity [median days absent (range)] by injury grouping

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Females Injuries</th>
<th>Females Severity (Range)</th>
<th>Males Injuries</th>
<th>Males Severity (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical facet joint dysfunction/nerve root pathology</td>
<td>9</td>
<td>4 (1-14)</td>
<td>3</td>
<td>1 (1-2)</td>
</tr>
<tr>
<td>Neck muscle spasm/strain/tear</td>
<td>23</td>
<td>5 (1-14)</td>
<td>4</td>
<td>4 (1-28)</td>
</tr>
<tr>
<td>Shoulder muscle/joint spasm/strain/tear/sprain</td>
<td>34</td>
<td>7 (1-42)</td>
<td>22</td>
<td>7 (2-28)</td>
</tr>
<tr>
<td>Other head/neck/arm pathology</td>
<td>13</td>
<td>7 (1-90)</td>
<td>7</td>
<td>4 (1-21)</td>
</tr>
<tr>
<td>Thoracic facet joint/rib dysfunction</td>
<td>22</td>
<td>7 (1-14)</td>
<td>7</td>
<td>7 (1-9)</td>
</tr>
<tr>
<td>Thoracic muscle spasm/strain/tear</td>
<td>25</td>
<td>6 (0-21)</td>
<td>8</td>
<td>6 (1-14)</td>
</tr>
<tr>
<td>Lumbar facet joint dysfunction/nerve root pathology</td>
<td>52</td>
<td>7 (1-28)</td>
<td>14</td>
<td>6 (0-14)</td>
</tr>
<tr>
<td>Lumbar muscle spasm/strain/tear</td>
<td>31</td>
<td>7 (0-28)</td>
<td>12</td>
<td>7 (2-14)</td>
</tr>
<tr>
<td>Lumbar pain undiagnosed</td>
<td>3</td>
<td>5 (4-7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluteal/hip muscle spasm/strain/tear</td>
<td>75</td>
<td>7 (1-28)</td>
<td>16</td>
<td>10 (1-21)</td>
</tr>
<tr>
<td>Thigh muscle spasm/strain/tear</td>
<td>111</td>
<td>14 (1-42)</td>
<td>34</td>
<td>7 (2-84)</td>
</tr>
<tr>
<td>Knee joint/ligament derangement</td>
<td>110</td>
<td>14 (1-90)</td>
<td>34</td>
<td>14 (1-180)</td>
</tr>
<tr>
<td>Peroneal tendinosis</td>
<td>13</td>
<td>14 (2-18)</td>
<td>3</td>
<td>21 (21)</td>
</tr>
<tr>
<td>Medial tibial stress syndrome</td>
<td>51</td>
<td>14 (1-365)</td>
<td>18</td>
<td>14 (5-21)</td>
</tr>
<tr>
<td>Stress fracture, including tibia/metatarsal</td>
<td>3</td>
<td>35 (7-180)</td>
<td>4</td>
<td>49 (35-180)</td>
</tr>
<tr>
<td>Tibialis posterior tendinosis</td>
<td>12</td>
<td>14 (1-42)</td>
<td>2</td>
<td>14 (7-21)</td>
</tr>
<tr>
<td>Calf muscle spasm/strain/tear</td>
<td>14</td>
<td>7 (1-28)</td>
<td>3</td>
<td>7 (2-7)</td>
</tr>
<tr>
<td>Lower leg pain undiagnosed</td>
<td>3</td>
<td>5 (1-7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achilles tendinopathy</td>
<td>38</td>
<td>14 (0-42)</td>
<td>4</td>
<td>7 (7-42)</td>
</tr>
<tr>
<td>Ankle instability/ligament sprain, including sinus tarsi</td>
<td>59</td>
<td>21 (0-56)</td>
<td>10</td>
<td>26 (6-56)</td>
</tr>
<tr>
<td>Ankle impingement/jarring/joint capsule sprain</td>
<td>12</td>
<td>14 (1-42)</td>
<td>4</td>
<td>28 (21-28)</td>
</tr>
<tr>
<td>Ankle pain undiagnosed</td>
<td></td>
<td></td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Foot muscle spasm/strain/tear</td>
<td>53</td>
<td>7 (2-270)</td>
<td>5</td>
<td>7 (1-14)</td>
</tr>
<tr>
<td>Sprain foot/toe joint</td>
<td>15</td>
<td>5 (1-14)</td>
<td>3</td>
<td>7 (4-14)</td>
</tr>
<tr>
<td>First metatarsophalangeal joint pain</td>
<td>8</td>
<td>7 (1-28)</td>
<td>3</td>
<td>14 (7-17)</td>
</tr>
</tbody>
</table>

Discussion

The purpose of this study was to report the incidence, severity and aetiology of injuries sustained in a musical theatre dance college over a 5-year period. In total 913 injuries were recorded with more injuries being reported in academic year 1 than year 2 and 3. Overall injury incidence was 1.46 injuries per 1000 hours (95%CI 1.34, 1.56) with a significant...
decrease between year 1, 2 and 3 (p<0.05). Most injuries were classified as overuse (71%
female, 67% male). Median time lost due to injury (severity) was 7 days with a slight
decrease for males after year 1 and female dancers reporting a small increase in year 2. There
was no significant sex difference for incidence or severity.

The present study reported a similar overall injury incidence to a systematic review of
musculoskeletal injury in dancers[3] across different genres and experience levels (1.46 vs
1.33 injuries per 1000 hrs exposure). The review included 2 musical theatre-based studies
based on professional dancers, both reported a predominance of overuse injuries. The first
study[2] was a self-report survey and reported 1.08 mean injuries per dancer, and also noted a
higher injury rate when based on Broadway compared to when on tour (1.36 vs 0.75 injuries
per dancer). The second study monitored injuries over a limited 7-week period[5] and
therefore is not comparable with the present study.

Pre-professional dance injury studies reported varying injury incidence depending on a
number of factors such as genre, workload, age and gender. Luke et al[10] noted a higher
self-report injury incidence (M 8.4/1000hrs; F 4.1/1000hrs) compared to physiotherapist
recorded incidence (M 5.5/1000hrs; F 2.5/1000hrs); these are higher than reported in the
current study even though the students had a much lower workload (13.3 – 16.5 hrs a week).
Two ballet studies reported contrasting incidence; Leanderson et al[11] reported 0.8/1000hrs
whilst Ekegren et al[12] reported 1.38/1000hrs, in both studies injury incidence increased
with age as well as workload. In Echegoyen et al’s prospective study across 3 genres [13]
Mexican folk and Spanish dancers reported a similar injury incidence (1.8 and 1.5/1000rs,
respectively) but modern dancers reported a significantly higher injury incidence
(4.0/1000hrs).
Injury incidence in previous studies seems to be linked to workload even when reported per 1000 hours, this contrasts with the present study where the recorded workload was greater than that reported in the majority of previous literature. The lower injury incidence in the current study, compared to previous literature, is potentially due to musical theatre dancers having a significantly greater aerobic capacity[1] and therefore are more resistant to fatigue, one of the main causes of overuse injury[14, 15].

The mean severity of injury in our study was higher than previous literature[3], this variance in severity may be due to the difference between professional and pre-professional environments. Within professional dance, a dancer needs to get back to performing as quickly as possible, whereas a student dancer on a three-year period of study is under less pressure to recover than is a professional dancer. Interestingly the injury severity in second year female dancers was higher in our study than all other years. Further investigation into this revealed one group of second year students had a small number of long-term injuries that still negatively influenced the median. The median severity was the same as that reported by Ekegren et al [12]. In their study they noted an increase to 10 days per injury in the third year. In the current study, there was a slight increase in median days off per injury in the second year, due to the aforementioned injuries in the female dancers, before it decreased in the third year. Our study reported a considerably higher percentage of intrinsic injuries (65%) than previously reported especially compared to professional dance studies[7, 16]. This difference in the intrinsic: extrinsic ratio may be due to several factors. For students, intrinsic factors such as muscle imbalances and weaknesses, and/or technique inconsistencies will potentially have an enhanced effect on injury occurrence than for professional dancers where these factors have been corrected or optimised as a result of their pre-professional training. For the professional dancer, extrinsic factors such as such as touring and dancing on different
floors[17] could have a greater impact, particularly when student dancers dance at a single location with uniform floors, as is the case in the current study.

In the current study overuse injuries accounted for 67-71% of the total injury count. This replicates previous studies that noted overuse injuries accounted for 57-64% of total injuries in professional dancers[7, 18] and 86% in pre-professional dancers [19]. A consequence of overuse injuries is that a specific mechanism for their injury cannot be recalled, in the current study 67% of participants did not provide a cause, therefore the development of an appropriate intervention is very difficult.

This study reported a high proportion of lower limb injuries which is consistent with previous research[3, 12, 20]. Repetitive jumping is an integral part of dance[21] and physical fitness decreases during the holiday periods can lead to increased risk of injury [7, 22]. Partner work/lifting in male dancers may be associated with the high prevalence of lower back and shoulder injuries. Although lower back injury rates declined over the academic years with no incidence in year 3, the mean incidence was still much higher than self-reported in the Dance UK surveys[14, 23]. Females had a much higher incidence of foot injuries than males (10% vs. 4%) that could be due to the female dancers having to carry out the same choreography as their male counterparts but wearing 6-inch heels.

This study has a number of limitations; as with Allen et al[7, 16] the injury surveillance tool was not tested for reliability or validity. There may also be author bias with regard to injury diagnosis, although regularly meetings with the physiotherapy team was used to minimise bias. Injuries may have been hidden by illness, as data were only included if absence or reduced participation was recorded as due to injury, not due to illness. Exposure was calculated on termly timetables and did not account for the occasional changes that may occur week to week for additional rehearsals, personal tutorials or cancellation of classes due
to performances. In addition, extra-curricular dance activity was not included in exposure
calculations, such as exam preparation, weekend or holiday rehearsals for corporate events or
pantomime contracts over the Christmas break that many third-year students participate in as
work experience. The intensity of the training sessions was also not measured and therefore a
better indication of overall workload was not possible.

In summary, this is the first prospective, longitudinal, epidemiological study to track injury
incidence and aetiology in a theatrical dance genre other than ballet or modern dance. Injuries
in this cohort of pre-professional musical theatre dancers followed a similar pattern as other
theatrical dance genres with a high proportion of lower limb and overuse injuries. In contrast
to previous research, the current study reported that injury incidence, rate and severity
decreased with progression through the course; this could be due to the superior physical
conditioning reported for this genre compared with other theatrical dance genres[1].

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