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# Epidemiology and management of ankle sprain injuries over seven seasons in an elite professional ballet company

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ABSTRACT

*Objectives:* To investigate the epidemiology and management of ankle ligament sprains over seven seasons in a professional ballet company.
*Design:* Descriptive epidemiology study.
*Methods:* Medical attention injury, time-loss injury, and exposure data pertaining to 140 professional ballet dancers were prospectively recorded by Chartered Physiotherapists over seven seasons (2015/16–2021/22); a period including the COVID-19 global pandemic.
*Results:* Sixty-nine ankle sprains (46 time-loss) in 45 dancers (32 %) were recorded: 51 sprains were classified as grade I, 15 were classified as grade II, and three were classified as grade III; 53 sprains affected only one ligament, whilst 16 were multi-ligament sprains. For time-loss injuries, median time-loss durations varied by grading (I - 31 days, II - 54 days, and III - 147 days) and the number of ligaments affected (one - 31 days, two - 54 days, three - 134 days, four - 137 days), with time-loss ranging from 1 to 188 days. Of the 46 time-loss ankle sprains, eight were *mild*, nine were *moderate*, and 29 were *severe*. The incidence rate (injuries·1000 $h^{-1}$) of medical attention ankle sprains was 0.073 (95 % CI: 0.046 to 0.117) in male dancers and 0.101 (95 % CI: 0.069 to 0.148) in female dancers, and the incidence of time-loss ankle sprains was 0.044 (95 % CI: 0.024 to 0.080) in male dancers and 0.064 (95 % CI: 0.040 to 0.103) in female dancers. No significant effect of sex was observed on either medical attention ($p = .304$) or time-loss ($p = .327$) ankle sprain incidence rates. Ten percent of dancers sustained multiple sprains across the seven seasons. Fifty and 39 % of ankle sprains in female and male dancers, respectively, were preceded by a history of ankle sprains. Jumping and landing (30 sprains) and non-dance movements (16 sprains) were the most common inciting movements. Bone bruising and synovitis were the most common concurrent pathologies.
*Conclusions:* Ankle sprains placed a considerable burden on the ballet company studied. These time-loss durations specified by number and grade of ligament sprain, injury history, and secondary pathologies can guide return-to-dance rehabilitation pathways.


## Practical implications

- The data presented can inform prognoses for ankle sprains based on the degree of structural damage and the number of ligaments affected.
- Early reporting of ankle sprains should be encouraged to mitigate the risk of exacerbation.
- Time-loss resulting from ankle sprains occurring outside of ballet accounted for 25 % of the time-loss observed in the study. This may reflect dancer's injury history, or the commonality of chronic ankle instability in this population; neuromuscular training or proprioception exercises may be a possible preventative.

## 1. Introduction

Ankle sprains are amongst the most burdensome injuries observed in professional ballet dancers, occurring at a rate of 0.27 injuries·1000 $h^{-1}$,[1] and resulting in a mean time-loss duration of 13–14 days per ankle sprain.[1,2] The movement profile of classical ballet may predispose dancers to ankle sprains. For example, ballet dancers jump[3] at a rate beyond that seen in sports such as basketball[4] and volleyball,[5] and initiate landings in a plantarflexed position. Furthermore, ballet dancers must dance *en pointe*/*demi-pointe*, supporting their entire bodyweight on a terminally plantarflexed foot.[6,7] In general populations, reoccurrence of

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ankle sprains was observed in 3 to 54 % of patients, whilst follow-ups after at least one year indicated that 5 % to 33 % were still experiencing related pain.[8] Thus, understanding the epidemiology and management of ankle sprain injuries in ballet dancers is fundamental for science and medicine practitioners seeking to mitigate and rehabilitate the injury in practice.

Commonly reported in both sport and dance are general epidemiological statistics encompassing all variations of an injury—i.e., a single injury severity for all sprain grades or ligaments affected. For example, research in association football reported ankle sprain time-loss ranging from 28 to 165 days,[9] whilst in ballet, ankle sprain time-loss ranges from zero to 58 days.[2] Although such studies give an overall picture of ankle sprain severity, they provide little insight into specific variations of the injury. Only one study has focussed specifically on the epidemiology of ankle sprains in ballet, and both the sample size (17 injuries) and detail (grading only) are limited.[10] As such, published data guiding the treatment of ankle ligament sprains is non-specific in reference to the grading of the sprain, the number of affected ligaments, and the tissues affected. More detailed data would aid in the prognosis of ankle sprains, and guide practitioners on appropriate return-to-dance timeframes.

The aim of this study was, therefore, to investigate the epidemiology and management of ankle ligament sprains in a cohort of professional ballet dancers over seven seasons.

## 2. Methods

A seven-season descriptive epidemiology design was used to investigate the epidemiology of ankle ligament sprains in professional ballet. The seven-season period reflected the total data available since the current injury recording system was introduced. The population was: all dancers employed as company members of The Royal Ballet between 8 August 2015 and 1 July 2022; this included a total of 140 professional dancers (75 female dancers, age: 29.2 ± 7.9; 65 male dancers, age: 29.1 ± 8.8), spanning the ranks of Apprentice, Artist, First Artist, Soloist, First Soloist, Principal, Character Artist, and Principal Character Artist. Dance events primarily took place at The Royal Opera House, London (~43 weeks per season); some external studios and theatres were used during touring periods (~3 weeks per season); dancers also had mid-season and summer breaks (totalling ~6 weeks per season). The study period included the COVID-19 pandemic, resulting in a shortened 2019–20 season (ending in March) and a fractured 2020–21 season (35 performances completed [~25 % of planned], 66 spread throughout the season). Ethical approval was granted by the local ethics committee in accordance with the Declaration of Helsinki. The STROBE Extension for Sport Injury and Illness Surveillance has been used to guide the reporting of this study.[11]

All exposure and injury data were recorded prospectively and stored using a cloud-based athlete data management system (Smartabase, Fusion Sport, Brisbane, Australia). Medical data were evaluated and recorded by in-house Chartered Physiotherapists using a standardised electronic form. Participants were typically seen by a physiotherapist within 24 h of the onset of an injury. Physiotherapists classified all injuries using the Orchard Sports Injury Classification System v.10.[12] Injury definitions were consistent with those previously used in epidemiology research in professional ballet.[1,2] Medical attention injuries were defined as "any musculoskeletal complaint that required medical attention from a physiotherapist". Time-loss injuries were defined as "any injury that prevented a dancer from fully participating in all dance-related activities that would normally be required of them for a period equal to or greater than 24 hours after the injury was sustained". At the conclusion of the data collection period, all medical data were extracted from the data management system and filtered to include only ankle sprain injuries. All authors met to review each injury record, and extract the following data relating to the injury: diagnosis, location, activity, inciting movement, surface, footwear, affected ligaments, grade classification, secondary pathologies, mode of onset, medical scans, medical interventions (i.e., injections, surgeries), associated time-loss, ankle sprain history, and the relationship to the activity. A history of ankle sprain injury was assessed based on either a prior ankle sprain in the data set, or a self-reported previous sprain during physiotherapy assessment. Sprain grading was classified based on imaging, or based on the physiotherapist's clinical impression where imaging was not completed, using the following three-grade system used elsewhere[13]:

- Grade I – structural damage on the microscopic level, with slight local tenderness and no instability.
- Grade II – a partial rupture with visible swelling and notable tenderness, but usually with little to no change in stability
- Grade III – a complete rupture with significant swelling and instability.

Exposure data were extracted from weekly timetables detailing the individualised class, rehearsal, and performance schedule of each dancer. All timetables were entered into the data management system by the company's Artistic Scheduling Manager using a bespoke form. To ensure accurate performance exposure, casting sheets for all performances during the study period were manually inspected for any last-minute cast alterations (e.g., due to injury or illness).

The number of days lost to injury was used to calculate the severity of ankle sprain injuries, which were defined as mild (0–7 days), moderate (8–28 days), or severe (>28 days). Incidence proportion was calculated for each season, where the numerator was the number of participants who sustained an injury during the season, and the denominator was the number of dancers in the company that season.

Poisson generalised linear mixed effects models were used to calculate the incidence rate of ankle ligament sprain medical attention and time-loss injuries. The target variable was the count of related (i.e., direct and indirect) medical attention and time-loss ankle ligament sprains experienced by each participant, offset by the log of their exposure duration. Sex was entered as a fixed factor, whilst participant identity was included as a random factor, accounting for the repeated measurements within individuals. Estimated marginal mean injury rates were extracted for male and female dancers, and back transformed to calculate the incidence rate per 1000 h of dance exposure. To facilitate comparisons with prior research, secondary models were calculated using dance-exposures (total count of classes, rehearsals, and performances) and dancer-seasons as the exposure variable. Statistical significance was set at $p < .025$, accounting for two primary outcome measures (medical attention and time-loss injuries); statistical comparisons were not made on secondary models. All analyses were conducted using R v.4.0.4 (R Foundation for Statistical Computing, Vienna, Austria).

## 3. Results

A total of 140 professional ballet dancers were included in the study, totalling 696 dancer-seasons (mean seasons per dancer: 4.9 ± 2.2). Demographics of the cohort, by season, are presented in Supplementary Table 1. Across the seven seasons, 25,226 individual dance events were scheduled (class: 3179, rehearsal: 21,243, performance: 804), encompassing 599,191 person-hours of exposure (class: 174,478, rehearsal: 253,557, performance: 171,157).

Sixty-nine medical attention ankle sprains were observed during the study period (female: 38; male: 31), 46 of which resulted in time-loss (female: 25; male: 21). Fifty-three sprains occurred as a direct result of ballet, whilst two were indirectly related, and 14 were unrelated. Of the 140 participants, 45 (32.1 %) sustained at least one medical attention ankle sprain (one sprain: 31; two sprains: 10; three sprains: 3; four sprains: 1), and 31 (22.1 %) sustained at least one time-loss ankle sprain (one sprain: 22; two sprains: 7; three sprains: 2). Incidence proportion by season is presented in Supplementary Fig. 1.

Across the 69 ankle sprains, 51 were classified as grade I, 15 were classified as grade II, and three were classified as grade III. Fifty-three

**Table 1**
Ankle sprain incidence rates (with 95 % CI) per 1000 h, per 10,000 exposures, and per dancer season.

| Injury type | Sex | Incidence rate | | |
|---|---|---|---|---|
| | | Per 1000 h | Per 10,000 exposures | Per 1000 dancer seasons |
| Medical attention | Female | 0.101 (0.069–0.148) | 1.58 (1.08–2.32) | 80.7 (54.8–119.0) |
| | Male | 0.073 (0.046–0.117) | 1.15 (0.72–1.83) | 59.9 (37.5–95.9) |
| Time-loss | Female | 0.064 (0.040–0.103) | 1.01 (0.63–1.61) | 51.7 (32.2–82.9) |
| | Male | 0.044 (0.024–0.080) | 0.69 (0.38–1.24) | 36.0 (19.9–65.3) |

sprains were classified as affecting only one ligament, whilst 16 were multi-ligament sprains (two ligaments: 10; three ligaments: 3; four ligaments: 3). The anterior talofibular ligament was the most commonly affected ligament ($n = 53$), followed by the calcaneofibular ligament ($n = 15$), deltoid ligament ($n = 10$), posterior talofibular ligament ($n = 5$), anterior inferior tibiofibular ligament ($n = 5$), and posterior inferior tibiofibular ligament ($n = 1$).

All ankle sprains across the seven seasons were managed conservatively. One or more forms of imaging were completed on 20 sprains (magnetic resonance imaging: 13; ultrasound: 11; X-ray: 5; computerised tomography: 1). Injections were used in three rehabilitations (corticosteroid: 2; hyaluronic acid: 1). Secondary issues diagnosed alongside, or during the rehabilitation of the ankle sprain, are presented in Supplementary Table 2.

The incidence of direct or indirect medical attention ankle sprains was 0.101 (0.069 to 0.148) injuries·1000 $h^{-1}$ in female dancers and 0.073 (0.046 to 0.117) injuries·1000 $h^{-1}$ in male dancers, whilst the incidence of direct or indirect time-loss ankle sprains was 0.064 (0.040 to 0.103) injuries·1000 $h^{-1}$ in female dancers and 0.044 (0.024 to 0.080) injuries·1000 $h^{-1}$ in male dancers. No significant effect of sex was observed on either medical attention ($p = .304$) or time-loss ($p = .327$) ankle sprain incidence rates. Incidence rates reported per 1000 h, per dance-exposure, and per dancer season are presented in Table 1.

Twenty-three ankle sprains did not result in time-loss. Of the 46 time-loss ankle sprains, eight were classified as *mild*, nine were classified as *moderate*, and 29 were classified as *severe*. The number of days lost as a product of the count and grade of affected ligaments is presented in Fig. 1. The overall burden of ankle sprains was 3.52 days of time-loss·1000 $h^{-1}$, whilst the most burdensome sub-category of sprains was grade I anterior talofibular ligament sprains (2.03 days of time-loss·1000 $h^{-1}$). Direct ankle sprains resulted in 1609 days of time-loss, whilst indirect sprains resulted in 96 days, and unrelated sprains resulted in 570 days. Risk matrices presenting injury burden by relationship, ligament, grade, count of affected ligaments, and ligament × grade combination are presented in Fig. 2.

Fifty percent (95 % CI: 34 to 66 %) of ankle sprains in female dancers, and 39 % (95 % CI: 23 to 54 %) of ankle sprains in male dancers were preceded by a history of ankle sprains, whilst in 23 % of all sprains, the dancer had a prior record of sprains on the same ankle. Sixty-seven sprains were classified as acute sudden onset injuries, whilst two were classified as acute gradual onset injuries, in which the dancer was pain-free prior to a session, and had pain by the conclusion of the session, with no obvious traumatic event. The count and percentage of injuries by inciting movement are presented in Supplementary Table 3. The count and percentage of injuries by footwear, location, and activity are presented in Supplementary Table 4.

## 4. Discussion

Across seven seasons at a professional ballet company, 69 ankle sprain injuries were recorded, resulting in 2275 days of time-loss. Most injuries occurred directly as a result of ballet—and particularly jumping and landing, and *pointe*-related movements—however, a considerable burden resulted from non-ballet injuries (e.g., tripping on the pavement, rolling an ankle whilst walking, etc.); 16 of the 69 sprains were indirect or unrelated, incurring an additional 666 days of time-loss (95 days per season).

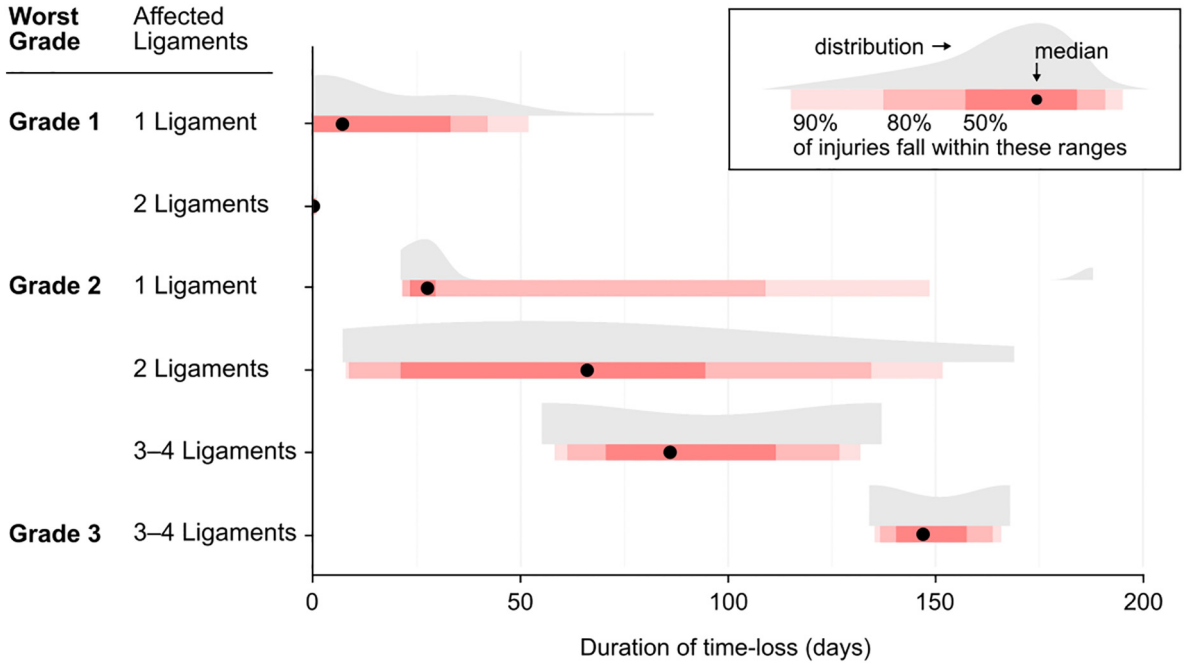


**Fig. 1.** Time-loss durations as a function of the worst grade and the number of ligaments affected in the sprain.

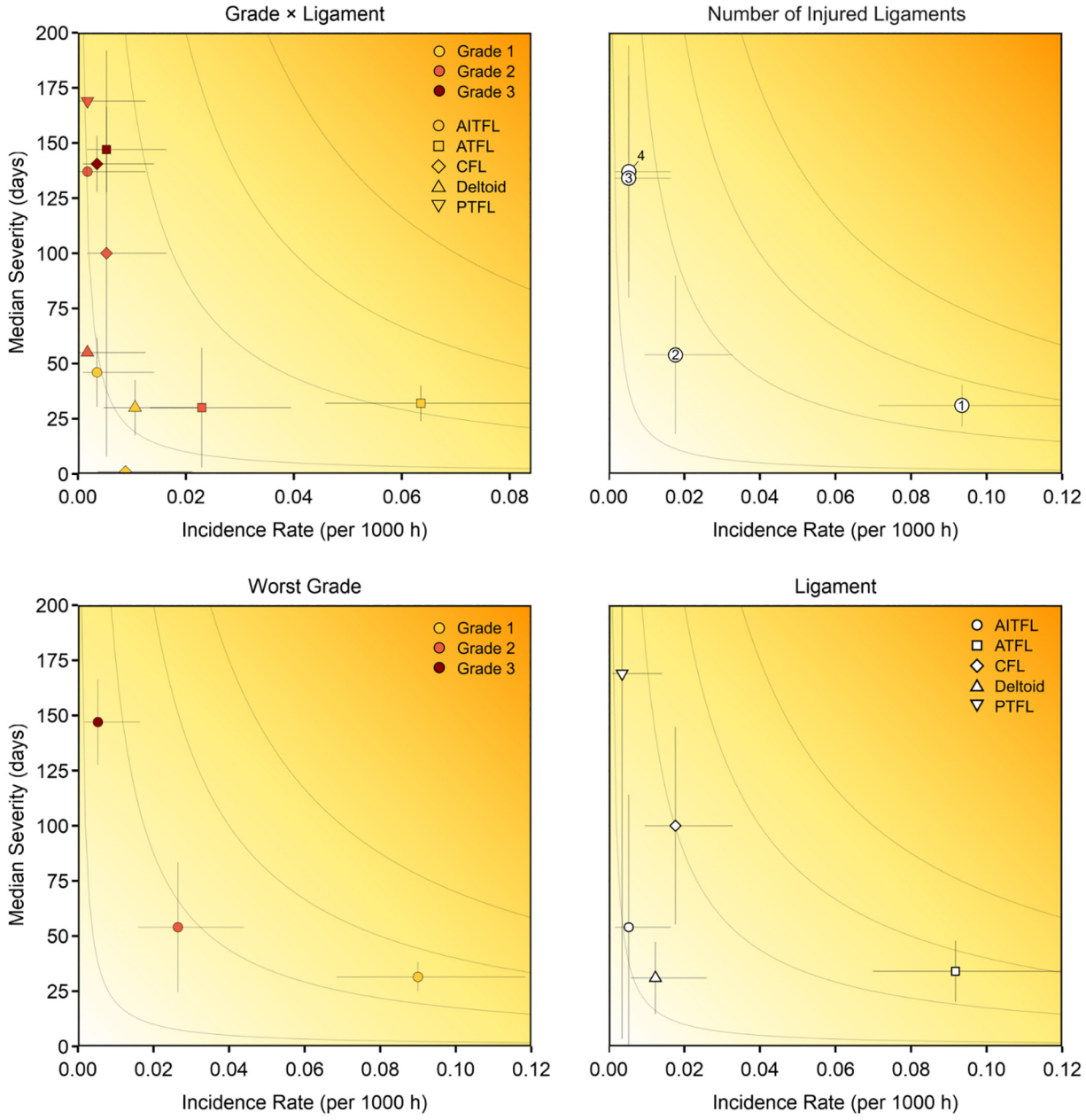


**Fig. 2.** Risk matrices illustrating the burden of ankle sprains by: A) the worst grade × ligament affected; B) the number of affected ligaments; C) the worst grade involved in the sprain; and D) the ligament affected. Error bars represent 95 % confidence intervals.

### *4.1. Ankle sprain injury incidence*

The present incidence rates for ankle sprain injuries per 1000 h are relatively low when compared with data in sports (basketball: 1.00; handball: 0.38–1.59; volleyball: 1.37–1.99),[14] though this is likely a result of the high exposure to dance activity observed in ballet.[15] Comparing incidence by ankle sprain injuries per 1000 person-seasons/person-years, the present values exceed those observed in track and field (29.9), are comparable to those observed in American football (59.4–60.6), speed skating (84.2), and association football (71.1), and are below those in basketball (173.5) and gymnastics (102.6).[14] The relatively high incidence of ankle sprains observed in ballet dancers is likely associated with the high volumes of sprain-inciting movements (i.e., jumping and landing, and pointe work) completed by this population.

A history of ankle sprains (i.e., a prior medical record, or patient-reported history) was evident in 41 % of ankle sprains, and a history of sprains to the same ankle was evident in 23 % of records. These values are comparable to recurrence rates in sport,[16] for example association football (32 %)[17] and basketball (26 %).[18] Ankle sprains are regularly cited as the most common re-injury in sport[19]; previous recommendations around bracing or strapping the ankle[20] are not viable strategies in ballet as they may limit the range of motion and negatively affect the aesthetics of the lower leg. Dancers with a history of ankle sprains (on either ankle[21]) should, therefore, direct additional effort towards neuromuscular training strategies to minimise the risk of recurrence.[20]

### *4.2. Severity*

Previous epidemiological studies in professional ballet dancers have reported time-loss durations of 13[1] and 14[2] days. Our findings demonstrate the necessity for greater nuance around ankle sprain prognoses, as median return-to-dance timeframes ranged from 0 to 147 days depending on the grade of sprain and the number of ligaments affected. Medical practitioners should be mindful, however, that variation exists

even within these categorizations (Fig. 1). Given this variation, practitioners should allow return-to-dance decisions to be guided by established frameworks,[22] and only use normative data as a rough estimate.

Previous studies in sporting populations[23,24] have reported lesser time-loss following ankle sprains. This may reflect the challenge associated with returning to the extreme biomechanical demands of professional ballet; for example, high volumes of jumping and landing,[25] *pointe*/*demi-pointe* positions,[6] and large active durations during rehearsal days.[15] The relatively large count of time-loss injuries compared to medical attention injuries may also reflect dancers attempting to continue dancing through mild sprains; this was evident on several occasions in the dataset, where dancers only reported an ankle sprain following an exacerbation, several weeks after the initial sprain. Science and medicine departments—and by extension, dance culture as a whole—must strive to build environments where dancers feel safe to report injuries, and educate dancers on recurrence risk should they choose to continue dancing.

### 4.3. Inciting movements

Previous research in professional ballet has attributed 22–38 % of all injuries to jumping and landing movements[2]; we found that jumping and landing movements were implicated in 38 % and 50 % of ankle sprain injuries in female and male dancers, respectively. The slightly lower percentage in female dancers may be due to the additional presence of *pointe* related ankle sprains. Surprisingly, despite the relatively high-risk position held *en pointe* (i.e., full weight bearing in maximal plantarflexion), only six of the 37 ankle sprains incurred by female dancers were associated with *pointe* work. Sixteen of the 69 ankle sprains occurred outside of ballet or physical training; as such, dancers should be aware that risk of injury is not exclusive to balletic activity.

### 4.4. Clinical implications

#### 4.4.1. Rehabilitation and management

In line with current recommendations,[27] all ankle sprain injuries—regardless of the sprain severity—were treated conservatively. Whilst some studies have suggested that surgical approaches to severe sprains may result in favourable outcomes regarding chronic ankle instability,[28] of the three grade III sprains recorded across the seven seasons, no recurrences were observed (in one, two, and three seasons of follow up). Chronic ankle instability can occur following ankle sprains,[29] characterised by persistent lateral ankle pain or recurrent episodes of the ankle giving way; in this regard, 23 % of ankle sprains were preceded by a sprain to the same ankle. Ankle joint hypermobility is common in dancers,[30] and further instability following a sprain may predispose the dancer to subsequent sprains or posterior ankle impingement. The latter alone is amongst the most burdensome injuries for ballet dancers.[2] To avoid re-sprains, neuromuscular training[20] or proprioception exercises[31] should, therefore, accompany a progressive return to full dance activities.

#### 4.4.2. Secondary pathologies

Secondary pathologies can extend recovery periods and lead to persistent ankle pain. In the authors' experience, long-term sequelae are common when sufficient time for ligament tissue healing and restoration of full baseline function is not allowed. Where imaging is not available, clinicians should remain cautious of bone bruising (usually of the talus) should there be continual discomfort and or swelling during weight bearing activity. Persistent synovitis of the ankle joint capsule in the chronic phase of healing can be an indicator of such underlying bone bruising. Physicians may recommend pharmacological management via non-steroidal anti-inflammatory medication, or judicious use of corticosteroid injection to reduce pain and swelling prior to exercise progression. Chronic ankle swelling may precede anterior ankle impingement, characterised by a painful reduction of weight bearing ankle dorsiflexion. Reduced dorsiflexion can negatively impact balletic performance and may predispose the dancer to further injury.

### 4.5. Strengths and limitations

There are several strengths regarding the data used in this study: all injury data were prospectively entered by Chartered Physiotherapists using a standardised entry form; a relatively consistent elite cohort was observed over a seven-year period; and individualised schedules were prospectively recorded for each participant facilitating accurate exposure data. Regarding data quality, however, we acknowledge that there may be some imperfections. Registers were not taken at rehearsals to confirm attendance, though given that dancers are contractually obliged to attend all sessions, we suggest that discrepancies would be relatively small given the total of 599,191 person-hours of exposure, and, therefore, would not have a meaningful effect on the results. Imaging was not completed for all scans, and multiple physiotherapists were involved in the study. There may, therefore, have been some inaccuracies or inconsistencies regarding the physiotherapist's clinical impression. Although the diagnostic accuracy of clinical assessments is unclear,[32] we have mitigated this risk where possible, with Chartered Physiotherapists using a standardised injury reporting form and diagnostic system.

The study period included the COVID-19 global pandemic, which affected multiple ballet seasons, and may have influenced injury rates (for example, due to an extended period of offload, changes in repertoire, etc.). Though it is beyond the scope of this study to hypothesise which results may and may not have been influenced by the pandemic, readers are advised to consider its potential effects when interpreting the results.

## 5. Conclusions

Ankle sprains place a considerable injury burden on professional ballet companies. There is a high variability in return-to-dance timelines (0–188 days), largely dependent on the grade and number of ligaments affected. Most ankle sprains were a consequence of jumping and landing activities, although *pointe* work and non-dance related sprains were also notable. Given the high recurrence rate of ankle sprains, dancers with a history of ankle sprains should undertake targeted neuromuscular training to mitigate re-injury risk.

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## Confirmation of ethical compliance

Ethical approval was granted by the local ethics committee in accordance with the Declaration of Helsinki.

St Mary's University, Twickenham Board of Ethics.

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## CRediT authorship contribution statement

**Joseph W. Shaw:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Adam M. Mattiussi:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Richard Clark:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Shane Kelly:** Conceptualization, Methodology, Investigation, Writing – review & editing.

## Declaration of interest statement

None.

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