



## Original research

# Injury incidence and severity in Chinese pre-professional dancers: A prospective weekly monitoring survey

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## ABSTRACT

**Objectives:** To determine dance injury incidence and severity in full-time Chinese pre-professional dancers.

**Study design:** Prospective weekly online monitoring survey.

**Methods:** Respondents were asked to record all dance-injury incidences between September 2020 and July 2021 using a remote weekly self-report injury monitoring tool. An inclusive definition of injury was used in this study to record all injuries, even if they didn't cause a cessation of training. Data were excluded if respondents completed <90 % of the survey period and had over 3 consecutive weeks of missing data.

**Results:** 450 individuals from 11 different schools were included in the analyses. A total of 1157 injuries were reported over a 30-week academic year. Injury prevalence was 64.9 % and injury incidence was 5.51 injuries per 1000 h. Forty-eight percent of the injuries were minor severity and 41 % were of moderate severity, and the main injury sites were knees (0.89/1000 h), lower back (0.80/1000 h), feet (0.58/1000 h) and groin (0.56/1000 h). Female dancers reported significantly higher injury prevalence and injury incidence, and higher rates of moderate to severe injuries than males. The university group reported higher injury incidence than the adolescent group ( $p < 0.05$ ), whereas the latter reported higher rates of moderate to severe injuries than the former ( $p < 0.001$ ).

**Conclusions:** The injury incidence found in this study (5.1 injuries/1000 h) is higher than most previous sets of data. Female dancers are at a higher risk of injury and reported higher levels of injury severity than male dancers, especially for the female adolescent group.

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## Practical implications

- Weekly online injury survey provides an easy and accurate method to monitor dancers' status remotely.
- Different dance genres/styles have different injury incidence and etiology but across all genres lower limb is main site of injury.
- Ballet training had the highest injury incidence.
- Female dancers are at a higher risk of injury and reported higher levels of injury severity than male dancers.
- Increased training hours are possibly linked to increased injury risk.

## 1. Introduction

Dance injury has been the focus of clinicians and scientists over the last five decades.<sup>1</sup> However, with different methods employed to record injury incidence and etiology, diverse degrees of accuracy and detail of injury data have been noted.<sup>2</sup> For instance, a number of studies used a retrospective injury recall questionnaire to self-report dance injury over different time periods, which has led to a wide range of dance injury prevalence from 3 % to 95 %.<sup>3–6</sup> The definition of injury has also changed over time, from time-loss or medical attention definitions to more recent attempts that encompass all injuries irrespective of whether medical attention is needed or time taken off.<sup>7,8</sup> Kenny et al. argue that the time-loss injury definition underestimates the injury burden in dance.<sup>9</sup>

Most published data indicated that the overall dance injury incidence is between 0.1 and 4.9 injuries per 1000 h,<sup>5–7,9–12</sup> mainly involving muscles and joints<sup>3,10,11,13,14</sup> at the lower back and lower extremities.<sup>3,5–8,10,11,13–17</sup> The main self-reported causes of injury

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were recurrence of old injury and fatigue.<sup>3,10,14,15</sup> Most of the aforementioned studies were mainly conducted in North America and Western European countries, and only a handful are from China. To the best of our knowledge, there are no published data yet on injury incidence referring to Chinese dancers.<sup>10,14</sup>

Chinese dance students can major in Dancology (this is a general full-time course that includes training in Basic Ballet Training, Chinese Classic Dance, Chinese Folk Dance, Contemporary Dance, Dance Choreography, and Dance Theory), Musical Theater (includes 6-year training in Chinese Folk Dance, Contemporary Dance and Musical Training in affiliated high school, and 4-year training in undergraduate education), and DanceSport (students have a four-year undergraduate education and usually have the previous six years of full-time training in the same dance genre). Furthermore, Chinese Dance includes both training in Chinese Classic Dance and Chinese Folk Dance that solely occur at dance conservatoires.

## 2. Aims

Therefore, the aim of this study was to determine dance injury incidence and severity in full-time Chinese pre-professional dancers.

## 3. Methods

Ethical approval was granted by the University of Wolverhampton (07/20/UOW).

### 3.1. The definition of dance injury

Dance injury was defined as a physical problem occurred while dancing, which manifests as pain or discomfort resulting in modified participation, dysfunction, reduced range of movement, or the immediate cessation of dance activity.<sup>9</sup> A new injury was defined as an injury that just happened, while an old injury was classified as any injury that materialized in the recent past and still affects the dancer. Injury severity was categorized as minor (I felt pain/uncomfortable, but it did not affect my dancing), moderate (I had to adapt my movement or could not do specific actions), moderate to severe (I had to stop dancing but < 1 day), and severe (I could not dance for 1 day or more).<sup>14</sup>

### 3.2. Questionnaires design

Two online questionnaires were developed based on the “Fit to Dance 2-Dancer and Dance Students Questionnaire” (2005),<sup>3</sup> changing it from a 12-month recall survey into a one-week recall survey. Both questionnaires asked for respondents' basic information (Q1–4), training and well-being condition (Q5–9), injury information (Q10–19), and treatment/rehabilitation (Q20–23) in one week. The first questionnaire asked for a complete previous injury history in the first week, and then the second questionnaire was sent to each respondent on a weekly basis, and it focused on new injuries and causes that occurred in the current week and whether injuries that occurred in previous weeks were still affecting their dancing.<sup>2</sup> Dance exposure (hours) includes the time dancers spent in class, rehearsal, performance, and body conditioning training. The surveys were translated into Chinese by a native Chinese speaker.

### 3.3. Questionnaire distribution

We distributed the questionnaire survey weekly on the online platform WenJuanXing (<https://www.wjx.cn/>), which is programmed to generate electronic links. The main investigator copied these links and sent them to participants on the social software Wechat (<https://www.wechat.com/>). Both WenJuanXing and Wechat meet the European General Data Protection Regulation (2020).<sup>36</sup>

The researchers used snowball sampling to recruit participants to complete the survey by initially inviting dance teachers and dance

students already known to the researchers and then requesting them to pass on information about the study to relevant students and dance schools. The participants were located across mainland China.

### 3.4. Online dance injury monitoring and procedure

Before the respondents could enter the survey, they had to sign an informed consent including parental consent for those respondents under 18 years old, and were reminded that their account names would be recorded for data tracking purpose. Each respondent could only fill out the questionnaire through one unique access account, and each account could only be completed once. Reminders were sent out to dance teachers and students on Wechat at the end of each week (Friday/weekend). The online survey was opened to full-time dance students located in China, from September 2020 to July 2021.

## 4. Inclusion and exclusion criteria

Our inclusion criteria required participants to be preprofessional dancers (age 12 yrs +) in full-time vocational dance training in a Chinese dance school or university and native Chinese speakers.

Based on pilot data,<sup>2</sup> weekly recall surveys were suggested to establish a higher quality of data throughout a study period; thus only data from participants with a 90 % weekly completion rate were analyzed. Participants who missed completing 3 consecutive weeks of the survey were also excluded from analysis. Only two contemporary dancers engaged in the second-semester survey; thus, their weekly data in injury prevalence were removed.

### 4.1. Data analyses

All weekly data for each respondent were combined by a software engineer through creating unique reference codes using their account names, students' numbers, and schools' names. Dance exposure, injury prevalence, injury incidence, and injury severity were calculated weekly basis, rather than over a year, as different dance schools had differing semester start dates and length of study periods. An injury was counted as one incidence, if it was repetitively reported on the same site over weeks. Injury Prevalence (IP) was calculated as the number of students who reported an injury divided by the total number of participants; this was calculated for both the whole survey period, and weekly (Weekly Injury Prevalence, WIP). Injury incidence was taken as the number of injuries per 1000 dance hours. Injury severity was calculated for each of the 4 severity categories as a percentage across the whole survey period and on a weekly basis.

All data were analyzed using descriptive statistical analysis within Excel and the SPSS version 28 (SPSS, Inc., Chicago, IL, USA). One-sample Kolmogorov–Smirnov test was used to examine whether the data were normally distributed. Mann–Whitney *U* test was used to analyze differences in age, height (cm), body mass (kg), BMI, weekly exposure (hours), and injury incidence between sex and different dance levels, while the Kruskal–Wallis *H* test was used to analyze these data per dance genre. Chi-square test was used to evaluate differences in IP between males and females, among dancers with different levels, and in diverse dance genres. Wilcoxon Signed-Rank Test was used to explore differences in weekly injury severity over 30 weeks between levels, sexes and genres.

## 5. Results

A total of 756 individuals from 16 different dance schools participated in the current survey over a 30-week academic year. After excluding data from 306 respondents who missed three consecutive weeks and did not achieve a 90 % completion rate, 450 respondents from 11 different schools were included in the analysis. This included 210 respondents who completed at least 22 surveys over

two semesters, and 240 completed at least 9 surveys in the first semester.

The 450 respondents included 110 Affiliation Middle School (AMS) students who were under 18-year-old (age  $15 \pm 1.33$  yrs., height  $167.9 \pm 6.16$  cm, body mass  $50.4 \pm 5.65$  kg, BMI  $17.8 \pm 1.26$ ), and 340 University Students (UNI) over 18-year-old (age  $20 \pm 1.19$  yrs, height  $168.2 \pm 6.37$  cm, body mass  $54.8 \pm 9.29$  kg, BMI  $19.3 \pm 2.83$ ); 79.8% of participants were females ( $n = 359$ ). The 450 respondents derived from six dance genres: Dancology ( $n = 222$ ), Ballet ( $n = 11$ ), Contemporary Dance ( $n = 12$ ), Chinese Dance ( $n = 126$ ), DanceSport ( $n = 59$ ), and Musical Theater ( $n = 20$ ) (Supplemental File A).

### 6. Weekly dance exposure

Weekly dance exposure for the full cohort was 32.2 h. However, the AMS group reported less dance exposure than the UNI group [29.3 h (95%CI 26.6, 32.1) vs 33.2 h (95%CI 31.4, 34.9),  $p < 0.05$ ]. Contemporary dance students spent longer hours in dance (41.2 h, 95%CI 31.7, 50.8) than the other 5 genres ( $p < 0.05$ ), followed by Dancology (33.7 h, 95% CI 31.5, 35.9), Ballet (32.4 h, 95% CI 20.7, 44.2), Chinese dance (32.2 h, 95% CI 29.6, 34.9), DanceSport (28.3 h, 95% CI 24.6, 32.0), and Musical Theater (21.8 h, 95% CI 15.3, 28.4). No sex difference for exposure was found in the full cohort, sub-groups and the six genres ( $p > 0.05$ ) (Supplemental File A).

### 7. Injury prevalence and incidence

Sixty-five percentage of our respondents ( $n = 292$ ) reported at least one dance injury. Female students demonstrated higher IP than their male counterparts in the full cohort ( $p < 0.05$ ) and the AMS group ( $p < 0.05$ ) (Table 1). The IP over the 30-week period in six genres was significantly different ( $p < 0.001$ ); ballet dancers reported the highest IP (90.9%,  $p < 0.01$ ), and then contemporary respondents reported significantly higher IP (83.3%,  $p < 0.05$ ) than the other four genres (Supplemental File B). The pattern of weekly injury prevalence (WIP) in each genre over the 30-week period was compared with the full cohort group the highest WIP in each genre was reported in the first three weeks of the first semester (Supplemental Fig. A and File B).

A total of 1157 injuries were reported, with an overall injury incidence of 5.51 injuries per 1000 h. The UNI group demonstrated a higher injury incidence (6.2 vs 3.39 injuries/1000 h,  $p < 0.05$ ) than the AMS group. Female students reported higher injury incidence than males in the full cohort (6.05 vs 3.39 injuries/1000 h,  $p < 0.01$ ), in the AMS group ( $p < 0.05$ ), and in the UNI groups ( $p < 0.05$ ), but no sex difference in each dance genre ( $p > 0.05$ ). A significant difference was also noted between the six dance genres ( $p < 0.001$ ): ballet reported the highest injury incidence (8.01 injuries/1000 h) compared with the other 5

genres ( $p < 0.05$ ); Dancology: 7.47 injuries/1000 h, Contemporary Dance: 4.94 injuries/1000 h, Chinese Dance: 3.67 injuries/1000 h, Musical Theater: 4.14 injuries/1000 h, and DanceSport: 2.18 injuries/1000 h (Table 1 and Supplemental File Ci).

### 8. Injury severity

Respondents reported primarily minor (46.9%) and moderate (42.5%) injuries across each subgroup. Comparing AMS and UNI sub-groups, adolescent students reported significantly higher percentages of moderate injuries (53.7% vs 37%,  $p < 0.001$ ), moderate to severe injuries (10.5% vs 3.4%,  $p < 0.001$ ) and severe injuries (11.5% vs 2.2%,  $p < 0.001$ ). The older group reported more minor injuries than the young group (57.4% vs 24.3%,  $p < 0.001$ ).

Compared to male students, females reported more moderate injuries for the AMS group (54.4% vs 43.9%,  $p < 0.001$ ), more moderate to severe injuries for the full cohort (6.1% vs 1.8%,  $p < 0.01$ ) and each subgroup (AMS: 10.5% vs 9.1%,  $p < 0.001$ ; UNI: 3.9% vs 1.5%,  $p < 0.05$ ), and more severe injuries for the full cohort (5.6% vs 2.1%,  $p < 0.001$ ) and the AMS group (11.6% vs 9.1%,  $p < 0.001$ ). Males reported more minor injuries than females in the full cohort (58.8% vs 44.4%,  $p < 0.01$ ) and the AMS sub-group (37.9% vs 23.5%,  $p < 0.05$ ) (Table 2).

Thirty-three respondents (7.3% of the full cohort) reported a total of 575 days off due to severe injuries, and these were female AMS dancers (12 respondents, 447 days off) (Table 1). Students from the Musical Theater ( $p < 0.01$ ) and Chinese Dance ( $p < 0.05$ ) reported higher rates of severe injuries than the other genres; the former reported more severe injuries than the latter (28.5% vs, 66%,  $p < 0.001$ ) (Supplemental File D).

### 9. Injury sites

The main anatomical sites with the highest injury incidence were knees (0.89 injuries per 1000 h), lower back (0.80 injuries per 1000 h), feet (0.58 injuries per 1000 h), groin (0.56 injuries per 1000 h), shoulder (0.49 injuries per 1000 h) and ankle (0.41 injuries per 1000 h). The AMS sub-group reported a higher incidence rate for the groin (1.02 vs 0.41 injuries/1000 h,  $p < 0.05$ ) than the UNI group, but the UNI sub-group was significantly higher for knees (0.75 vs 0.93 injuries/1000 h,  $p < 0.01$ ); feet (0.36 vs 0.66 injuries/1000 h,  $p < 0.01$ ) and shoulders (0.2 vs 0.59 injuries/1000 h,  $p < 0.001$ ).

Female students reported higher injury incidence than males for the lower back for the full cohort (0.92 vs 0.35 injuries/1000 h,  $p < 0.05$ ) and the AMS sub-group (1.5 vs 0.19 injuries/1000 h,  $p < 0.05$ ), knees for the full cohort (1.02 vs 0.37 injuries/1000 h,  $p < 0.001$ ) and sub-groups (UNI: 1.05 vs 0.48 injuries/1000 h,  $p < 0.01$ ; AMS: 0.93 vs 0.06 injuries/1000 h,  $p < 0.05$ ), shoulder for the full cohort (0.56 vs 0.21

**Table 1**  
Injury incidence and days off due to severe injuries.

	Full cohort (n = 450)		AMS (n = 110)		UNI (n = 340)	
Injuries	1157		188		969	
Injuries/1000 h	5.51 ± 8.11		3.39 ± 4.64		6.20 ± 8.85*	
IP	64.9%		63.6%		65.3%	
Days off (the number of students)	33		13		20	
Days off (in total)	575		449		126	
Days off per dancer	17.4 ± 28.35		34.5 ± 39.92		6.3 ± 4.01	
Sex	Male (n = 91)	Female (n = 359)	Male (n = 23)	Female (n = 87)	Male (n = 68)	Female (n = 272)
Injuries	165	992	19	169	146	823
Injuries/1000 h	3.39 ± 5.53	6.05 ± 8.57†	1.53 ± 2.84	3.88 ± 4.91*	4.01 ± 6.07	6.74 ± 9.35*
IP	55%	67.4%*	43.5%	69%*	58.8%	66.9%
Days off (the number of students)	6	27	1	12	5	15
Days off (in total)	32	543	2	447	30	96
Days off per dancer	5.3 ± 5.05	20.1 ± 30.71	2 ± 0	37.3 ± 40.43	6.0 ± 5.34	6.4 ± 3.70

Please note that AMS means Affiliation Middle School dance students; UNI means University dance students; IP means Injury Prevalence.

\*  $p < 0.05$ .

†  $p < 0.01$ .

**Table 2**  
Injury severity.

	Full cohort (n = 450)		AMS (n = 110)		UNI (n = 340)	
Minor	46.9 %		24.3 %		57.4 % <sup>†</sup>	
Moderate	42.5 %		53.7 % <sup>†</sup>		37 %	
Moderate to severe	5 %		10.5 % <sup>†</sup>		3.4 %	
Severe	5 %		11.5 % <sup>†</sup>		2.2 %	
Sex	Male (n = 91)	Female (n = 359)	Male (n = 23)	Female (n = 87)	Male (n = 68)	Female (n = 272)
Minor	58.8 % <sup>†</sup>	44.4 %	37.9 % <sup>*</sup>	23.5 %	59.5 %	56.5 %
Moderate	37.3 %	43.8 %	43.9 %	54.4 % <sup>†</sup>	37.5 %	37.2 %
Moderate to severe	1.8 %	6.1 % <sup>†</sup>	9.1 %	10.5 % <sup>†</sup>	1.5 %	3.9 % <sup>*</sup>
Severe	2.1 %	5.6 % <sup>†</sup>	9 %	11.6 % <sup>†</sup>	1.6 %	2.5 %

Please note that AMS means Affiliation Middle School dance students; UNI means University dance students; IP means Injury Prevalence.

\* p < 0.05.

† p < 0.01

injuries/1000 h, p < 0.01) and the UNI sub-group (0.66 vs 0.28 injuries/1000 h, p < 0.05), and groin in the UNI sub-group (0.48 vs 0.15 injuries/1000 h, p < 0.05) (Table 3).

### 10. Discussion

This study aimed to determine dance injury incidence and severity in full-time Chinese pre-professional dancers using a weekly remote self-report injury tool. To our knowledge, this is the first study reporting prospective injury incidence for Chinese dancers. Most published studies from western populations indicated that dance injury incidence was below 5 injuries per 1000 h.<sup>7,9–12,18</sup> The present study used an inclusive injury definition and reported injury incidence of 5.51/1000 h, which is substantially higher than that from previously published data (4.4 injuries/1000 h<sup>12</sup> and 1.46 injuries/1000 h<sup>11</sup>) and supports the concept that the time-loss injury definitions underestimate the injury burden in dance.<sup>9</sup>

The highest WIP in each genre was found to be in the first three weeks of semester one and may be linked to a suddenly increased training load after returning from the summer holiday.<sup>19</sup> This wasn't repeated in the second semester, possibly because the initial three weeks of semester two were online dance training (weeks 14–16) due to the COVID-19 lockdown. The latter is supported by a previous study on a similar participant group (i.e., Chinese dancers) which revealed that the injury prevalence percentage dropped significantly during the COVID-19 lockdown.<sup>14</sup> A possible explanation might be that since dancers' training occurred at home in a smaller space (3–5 m<sup>2</sup>), the training load was reduced due to the confines preventing large jumps and traveling sequences.

Most previous studies indicated that there is no significant sex difference in injury prevalence,<sup>5,14</sup> injury incidence,<sup>6,11,12,17,19–21</sup> or severity,<sup>11</sup>; and some studies found male dancers with higher injury

prevalence,<sup>10,22</sup> incidence<sup>16,23</sup> and severity<sup>12</sup> than their female counterparts. However, contrary to the aforementioned findings, the present study is consistent with a few studies that female dancers self-reported higher rates of injury prevalence,<sup>23</sup> injury incidence,<sup>24–26</sup> and higher levels of injury severity<sup>25</sup> than male dancers.

Females reported higher IP than males, this phenomenon could be linked to increased risk factors such as the delayed onset of growth and maturation, delayed menarche, and menstrual irregularities.<sup>27</sup> The increased injury incidence in female dancers at the lower back, groin, and shoulders could also be linked to the extreme flexibility required at these joints, especially for female dancers,<sup>28–30</sup> and how it is attained. These requirements potentially result in impingement-induced instability, compensatory osseous and muscular pathology.<sup>31</sup> Therefore, it has been argued that high levels of range of movement significantly increase overall injury rates.<sup>31,32</sup>

The present study also found that severe (measured by days off) injuries were mainly reported by female AMS dancers from Musical Theater and Chinese Dance, whereas the AMS group as a whole reported higher injury incidence on the groin (p < 0.05) than the UNI group (Table 3). Only a few studies have indicated hip injuries at a high prevalence and incidence.<sup>15,17,33,34</sup> This high prevalence of groin/hip injuries could be due to students in the affiliation middle dance schools with limited hip range of movement trying to force their external hip rotation to achieve the required extreme flexibility in the hips required from grades 1 to 3 in Musical Theater and Chinese Dance courses (aged 12–15).

The UNI group reported higher injury incidence than the AMS group (p < 0.05). The higher incidence may be linked to their educational background. Chinese dance universities recruited both high-school students with part-time training (3-year) and students from pre-professional secondary schools with full-time training (6–7 year),<sup>14</sup> resulting in group cohorts of very mixed abilities. Stephens et al.<sup>11</sup>

**Table 3**  
Injury incidence in main injury sites.

	Full cohort (n = 450)		AMS (n = 110)		UNI (n = 340)	
Shoulders <sup>†</sup>	0.49		0.20		0.59 <sup>†</sup>	
Lower back	0.80		1.23		0.67	
Groin <sup>*</sup>	0.56		1.02 <sup>*</sup>		0.41	
Knees <sup>†</sup>	0.89		0.75		0.93 <sup>†</sup>	
Ankles	0.41		0.39		0.41	
Feet <sup>†</sup>	0.58		0.36		0.66 <sup>†</sup>	
Sex	Male (n = 91)	Female (n = 359)	Male (n = 23)	Female (n = 87)	Male (n = 68)	Female (n = 272)
Shoulders <sup>*</sup>	0.21	0.56 <sup>†</sup>	0.00	0.25 <sup>*</sup>	0.28	0.66 <sup>*</sup>
Lower back <sup>*</sup>	0.35	0.92 <sup>*</sup>	0.19	1.50	0.41	0.73
Groin <sup>*</sup>	0.25	0.64	0.53	1.15	0.15	0.48 <sup>*</sup>
Knees <sup>†</sup>	0.37	1.02 <sup>†</sup>	0.06	0.93	0.48	1.05 <sup>†</sup>
Ankles	0.34	0.42	0.17	0.44	0.39	0.42
Feet	0.69	0.56	0.17	0.41	0.86	0.60

Please note that AMS means Affiliation Middle School dance students; UNI means University dance students; IP means Injury Prevalence; all figures are in the number of injuries per 1000 h.

\* p < 0.05.

† p < 0.01.

suggested that one of the contributing factors to injury is increases in training intensity. Compared to the AMS group, the higher reported injury incidence of the UNI group may be because of the recurrence of old injury; previous studies<sup>3,10,14</sup> had reported that reoccurrence of an old injury was the primary issue. Such conditions combined with older age ( $p < 0.01$ ) and longer exposure ( $p < 0.05$ ) potentially increase the risk of injury. Previous studies also indicated that age<sup>35</sup> and weekly exposure<sup>8</sup> were associated with dance injury.

## 11. Strengths and limitations

Based on previous studies' insights<sup>2,7,8</sup> weekly recall surveys should establish a higher quality of data throughout the study period, and the present study established a higher data inclusion criteria than two similar studies,<sup>7,8</sup> which potentially improved the quality of included data.

Within the survey the definitions of injury severity could have misinterpreted by respondents with the use of both "moderate" and "severe" across a number of categories: moderate, moderate to severe, and severe. Definitions were provided but not necessarily read by the respondents.

Out of a total of 450 participants, 240 only took part in the first semester rather than both semesters. However, this limitation didn't affect the vast majority of the reported results since the authors calculated them weekly rather than over a year. This study also reported an unequal distribution of male and female dance students (20 % vs 80 % of the participants), which may have influenced the sex difference in IP, injury incidence and injury severity.

## 12. Conclusions

To our knowledge, this the first prospective study to determine dance injury incidence and severity in full-time Chinese pre-professional dancers using a weekly remote self-report injury monitoring tool. Injury incidence in Chinese student dancers is higher than that reported in studies on dancers from Western countries. Chinese female dancers are at a higher risk of dance injury compared to male counterparts. Younger dancers reported lower injury incidence than their older colleagues, but higher levels of injury severity, especially in the groin.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jsams.2023.09.021>.

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## Confirmation of ethical compliance

Ethical guidelines have been clearly followed with the appropriate Ethics committee (University of Wolverhampton) and approval number within the manuscript (07/20/YD2/UOW).

## CRediT authorship contribution statement

**Yanan Dang:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft. **Yiannis Koutedakis:** Writing – review & editing, Supervision. **Ruoling Chen:** Writing – review & editing. **Matthew Wyon:** Conceptualization, Methodology, Data curation, Writing – original draft.

## Declaration of interest statement

None.

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