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Incidence and prediction of ankle injury risk: a prospective cohort study on 91 contemporary preprofessional dancers

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ABSTRACT

Objectives This study examines the incidence of ankle injuries and identifies ankle injury risk among contemporary preprofessional dancers.

Methods A total of 91 first-year contemporary preprofessional dancers were prospectively followed during one academic year. Self-reported ankle injuries, assessed with the Oslo Sports Trauma Research Centre questionnaire, were categorised as all complaint ankle injuries, substantial ankle injuries or time-loss ankle injuries. In addition, ankle injuries leading to medical attention were included. Regression analyses were used to determine the association between potential risk factors (dancer characteristics, history of ankle injury in the previous year, ankle range of motion and dorsiflexion) and ankle injuries.

Results The 1-year ankle injury incidence proportion was 18.7% (n=17), 8.8% (n=8), 15.4% (n=14) and 7.7% (n=7), respectively, for all complaint ankle injuries, ankle injuries requiring medical attention, time-loss injuries and substantial injuries. Being male (OR=0.27; 95% CI 0.09 to 0.75) and being a student of the Bachelors in Dance and Education (OR=0.27; 95% CI 0.08 to 0.97) were univariately associated with a lower risk of an ankle injury.

Conclusion Almost 20% of first-year preprofessional dancers reported an ankle injury, with more than 80% of the dancers reporting that their injury leads to dance time loss. Males and students of the bachelors in dance and education were at lower risk of ankle injuries. As ankle injuries are common among dancers, studies with larger sample sizes, a more heterogeneous population (eg, different dance styles) and longer follow-up periods are necessary to evaluate the impact of ankle injuries in further detail.

Key messages

What is already known?

- Pre-professional dancers have a high prevalence of injuries, with the ankle being one of the most frequently injured locations
- Until now, no studies investigated factors associated with a higher ankle injury risk among preprofessional dancers.

What are the new findings?

- Preprofessional dancers are at high risk for ankle injuries, with the majority of these injuries leading to dance time loss and thereore injury prevention programmes in dance universities should focus on the prevention of ankle injuries.
- Dance universities must especially create awareness in women and students of the bachelors in dance as they seem to be more prone to ankle injuries.
- Ankle injury incidence proportion varies greatly depending on the injury definition. To gain insight into the number of dance injuries in different target populations, we recommend using standardised injury definitions.

INTRODUCTION

Preprofessional dancers must endure highly intensive academic training from a relatively young age with many training hours to become a professional dancer.[1] These demands can cause health hazards[2] and may lead to discomfort, medical treatment, absence from dance activities, study delay and even dropping out of college.

Preprofessional dancers have a high prevalence of overuse injuries, ranging from 56% to 72%, with the ankle being one of the most frequently injured locations with a prevalence of 17%–33%.[2–7] In preprofessional ballet dancers, evidence has indicated that ankle injuries resulted in an absence from ballet for more than a month.[8] After sustaining an ankle injury, up to 76% of modern and ballet dance majors developed chronic ankle instability, which can affect the performance of dance[9] and cause dancers to retire from professional dancing.[10] Considering the high prevalence and impact of ankle injuries among dancers, it is important to identify the risk factors for sustaining an ankle injury to develop preventive measures. Previous studies have determined risk factors for general dance-related injuries[1 11] or for injuries in specific body regions (eg, lower extremity).[12] To our knowledge, no study has identified factors specifically for ankle injuries among preprofessional dancers.

A first step towards the development of preventive measures for injuries is the evaluation of the injury incidence.[13] To date, different ankle injury definitions (eg, injury leading to time-loss or medical attention) are used to describe the incidence of ankle injuries among dancers.[8 14 15] Clarsen *et al* proposed an injury surveillance method that also takes overuse into account.[16] Presenting the incidence of ankle injuries according to this method will capture a more comprehensive picture of the burden of ankle injuries in preprofessional dancers and may aid early detection of the problem. This study aimed to examine the incidence of ankle injuries during the academic training of preprofessional dancers, using different injury definitions (ie, all complaints, medical attention, time-loss and substantial ankle injuries). The second aim was to identify factors associated with a higher ankle injury risk among first-year contemporary preprofessional dancers.

METHODS AND MATERIALS

Subjects

This prospective cohort study was performed among first-year contemporary preprofessional dancers (full time) at the Codarts University of the Arts, Rotterdam, the Netherlands. Preprofessional dancers were included from the bachelors in dance (BD) and bachelors in dance and education (BDE) from the academic years 2017–2018 and 2018–2019 (September–June). All dancers provided written informed consent before participation.

Baseline measurements

At the start of the academic year, all BD and BDE dancers completed an intake questionnaire including questions on age (years), sex, weight (kg), height (cm) and history of a long-lasting ankle injury during the previous year (ie, any physical complaint resulting in a full time-loss of dance activity (participation in class, rehearsal, performance, practice, etc) for 1 week or more beyond the day of onset). Throughout one academic year, dance exposure in hours (ie, time exposure) was retrieved, for both BD and BDE, respectively, from the students' training schedule.[17]

In addition, all preprofessional dancers underwent a physical screening, including ankle range of motion (ROM) and dorsal flexion of both ankles. ROM was assessed by the in-house physiotherapist, specialised in dance medicine, and was categorised as follows: normal, hypomobile or hypermobile. The classification was based on the experience of the physiotherapist.

To determine both ankles' dorsal flexion, all dancers performed the weight-bearing lunge test.[18] For this test, the dancers were asked to place their foot so that an imaginary line drawn through the heel and big toe would be aligned with a tape measure on the floor. Furthermore, a vertical line was drawn on the wall in line with the tape measure. Dancers were instructed to lunge forward with their knee touching the wall while their foot remained flat on the ground. Subsequently, due to this position, the ankle was placed in maximal dorsiflexion, and the distance from the wall to the great toe was measured in centimetres (each centimetre corresponds to approximate ankle dorsiflexion of 3.6°).[18]

Follow-up measurements

Both cohorts (2017–2018 and 2018–2019) were followed for one academic year (September–June). During the academic year, all preprofessional dancers were asked to complete monthly questionnaires using the performing artist and athlete health monitor. This web-based system monitors the physical and mental health of performing artists and athletes.[2 19 20] If the monthly questionnaire was not completed, a reminder e-mail was sent out to the dancers. Data of follow-up measurements were included in the current study if the dancer completed at least 30% of the questionnaires during one academic year.[2]

Monitoring ankle injuries during the academic year

Three different methods were used to monitor ankle injuries:

1. The monthly questionnaire included the Oslo Sports Trauma Research Centre (OSTRC) Questionnaire on Health Problems.[16] This questionnaire contains four key questions on the consequences of an injury on participation/performance and to what extent the respondent experienced symptoms. Each question ranged between 0 (no problem) to 25 (cannot participate at all or severe symptoms) on a 4-point or 5-point scale. The scores of the four questions were summed to calculate a severity score from 0 (no health problem) to 100 (cannot participate at all because of severe health problems).[16] If the severity score was 0, the questionnaire was classed as complete. If the score was greater than 0, the student was asked what type of health problem they referred to: physical injury, mental health problem or other problem (eg, illnesses such as the influenza, fever, accidents or operations). If the preprofessional dancers indicated a physical injury, the dancer was automatically directed to an injury registration form based on an international consensus statement on injury surveillance methodology for football to collect further details (eg, location, history, acute or gradual onset).[21] For this study, only ankle-related health problems were included.
2. All preprofessional dancers had access to the health team affiliated with the university, which included three physiotherapists. All medical attention ankle injuries were reported on a standard injury report form by the physiotherapists. The report form included details as to the type of injury and a diagnosis.
3. Preprofessional dancers who reported an ankle injury in the monthly questionnaires were asked to report the number of days they could not fully participate in dance training or performances due to their ankle injury over the previous 4 weeks.

Ankle injury definitions

Ankle injuries were categorised by using the following four definitions:

1. All complaints ankle injury: any physical complaint located at the ankle resulting in a severity score higher than zero on the OSTRC questionnaire, irrespective of the need for medical attention or time-loss from dance activities.
2. Substantial ankle injury: an ankle injury leading to moderate or severe reductions in training volume, sports performance or a complete inability to participate in dance (score ≥13 on question 2 or 3 of the OSTRC questionnaire).[16]
3. Ankle injury leading to dance time-loss: an ankle injury resulting in the inability to complete a rehearsal, performance or class (or a subsequent rehearsal, performance or class) one or more days beyond the day of onset.[17 21]
4. Ankle injury leading to medical attention: an ankle injury resulting in a dancer seeking care from the medical team (ie, physiotherapist) within the university.[17 21]

Injuries reported in two or more consecutive months on the same ankle were considered the same ankle injury (ie, ongoing injury). Injuries reported across non-consecutive months, or injuries on the contralateral ankle during follow-up, were considered unique ankle injuries.

Statistical analysis

All analyses were performed with the SPSS V.25.0. (IBM) with the significance level set to 0.05. Descriptive statistics were used to describe the baseline characteristics of the preprofessional dancers (ie, age, gender, body mass index (BMI), dance exposure) and the outcome of the physical tests at the start of the academic training (ie, ankle ROM and ankle dorsal flexion) using means and SD for continuous data, and numbers and percentages (%) for categorical data.

The incidence proportion (IP) of ankle injuries (ie, all, substantial, time-loss and medical attention) was calculated by dividing the number of dancers that reported at least an all complaints ankle injury/substantial ankle injury/time-loss ankle injury/medical attention ankle injury during the academic year divided by the total number of respondents.[22] The injury incidence rate was calculated as the number of injuries (ie, all, substantial, time-loss and medical attention) per 1000 hours spent on dance activities.[21] The corresponding 95% CIs were obtained using the following formula: (#injuries/exposure ±1.96 SE) * 1000.[22]

To identify factors associated with the occurrence of ankle injuries among the preprofessional dancers, both univariate and multivariate regression models were performed on leg-level, using generalised estimating equations. These models take into account the association between two legs within one person. Potential factors included age (years), sex (male), BMI (kg/m^2), educational programme (BDE), history of a long-lasting ankle injury during the previous year, ankle ROM and ankle dorsal flexion. The independent variable, ankle ROM, was dichotomised into normal and abnormal for the regression analyses. A hypomobile and hypermobile ankle was defined as an abnormal ankle ROM and a normal ankle ROM used as the reference category. Variables from the univariate analyses with a p<0.20 were included in the multivariate analysis. In addition, to determine the number of factors to be included in the multivariate analysis, we accounted for the one in ten rule.[23 24] The regression analyses' results were expressed in ORs with their corresponding 95% CIs.

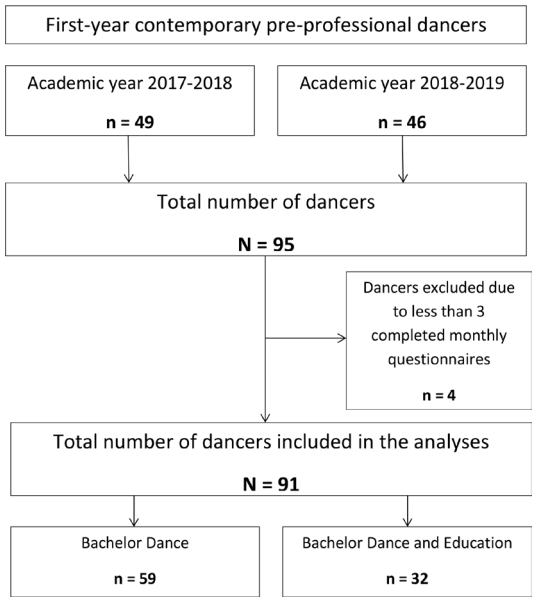

Figure 1 Flow chart of the preprofessional dancers included in the current study.

Patient and public involvement

Patients or the public were not involved in this research's design, conduct, reporting or dissemination plans.

RESULTS

Response and baseline characteristics

During the academic years of 2017–2018 and 2018–2019, 95 first-year contemporary preprofessional dancers were invited for the medical screening and were asked to fill in the questionnaires each month. All dancers gave consent to participate. 72.5% of the dancers completed all 9 monthly questionnaires. Four dancers completed less than 30% of the questionnaires. Therefore, 91 dancers (59 BD, 32 BDE) were included in the analyses, resulting in a response rate of 95.8% (figure 1). Baseline characteristics of these 91 pre-professional dancers are shown in table 1.

Incidence of ankle injuries

Across the two academic years, 17 preprofessional dancers reported a total of 33 ankle injuries. Of these, 23 were unique cases. The remaining 10 ankle injuries were ongoing injuries. These injuries were recorded in at least two consecutive questionnaires and therefore were not

Table 1 Characteristics of dance students at baseline

	Total population N=91	Bachelors dance N=59	Bachelors dance education N=32
Age (years), mean±SD	19.2±1.5	18.9±1.0	19.8±2.1
Sex (male)	27 (29.7%)	27 (45.8%)	0 (0.0%)
BMI (kg/m^2), mean±SD	21.2±2.0	20.9±1.6*	21.8±2.4
Dance exposure (total hours per academic year/student)	1055.5±276.2	1257.8	682.5
History of a long-lasting ankle injury in the past year	2 (2.2%)	1 (1.7%)	1 (3.1%)
Physical tests at the start of the training			
Ankle range of motion			
Left			
Hypomobile	6 (6.6%)	5 (8.5%)	1 (3.1%)
Normal	77 (84.6%)	46 (78.0%)	31 (96.9%)
Hypermobile	8 (8.8%)	8 (13.6%)	0 (0.0%)
Right			
Hypomobile	5 (5.5%)	5 (8.5%)	0
Normal	77 (84.6%)	45 (76.3%)	32 (100.0%)
Hypermobile	9 (9.9%)	9 (15.3%)	0 (0.0%)
Ankle dorsal flexion (wall-to-toe distance in cm) (SD)			
Left	14.4±2.6‡	14.5±2.7§	14.1 ± 2.4¶
Right	14.8±2.7‡	14.7±2.6§	14.9 ± 2.9¶

Presented in n (%), unless otherwise stated.
*n=4 missing.
†Measured with the weight-bearing lunge test.
‡n=4 missing.
§n=3 missing.
¶n=1 missing.
BMI, body mass index.

categorised as unique injuries. The ankle injury IP for one academic year was 18.7% (n=17), 8.8% (n=8), 15.4% (n=14) and 7.7% (n=7) for all complaints ankle injuries, medical attention ankle injuries, time-loss ankle injuries and substantial ankle injuries, respectively.

The 59 BD students spent on average 1257.75 hours per academic year on dance activities, resulting in a total exposure of 74 207.25 hours during the year. On average, the 32 BDE students spent 682.50 hours per academic year on dance activities, resulting in a total exposure of 21 840 hours across the academic year. The total exposure for all dance students was 96 047.25 hours. The total time equates to incidence rates (ankles injuries/1000 dance exposure hours) of 0.24 (95% CI 0.14 to 0.34), 0.08 (95% CI 0.03 to 0.14), 0.10 (95% CI 0.04 to 0.17) and 0.17 (95% CI 0.08 to 0.25) for all complaint ankle injuries, medical attention ankle injuries, time-loss ankle injuries and substantial ankle injuries, respectively.

Who is at risk for an ankle injury?

The univariate analyses indicated a negative association for males (OR=0.27; 95% CI 0.09 to 0.75) and dancers from the BDE (OR=0.27; 95% CI 0.08 to 0.97) with the occurrence of an ankle injury during the academic year (table 2). These associations were no longer significant in the multivariate analysis; males (OR=0.36; 95% CI 0.12 to 1.12; p=0.08) and BDE (OR=0.48; 95% CI 0.12 to 1.89; p=0.29).

DISCUSSION

In the current study, 91 first-year contemporary preprofessional dancers from the BD and BDE were included. Almost 20% of the dancers (n=17) reported an ankle injury, with a total of 23 unique ankle injuries throughout the academic year. Males and dancers on the BDE had a lower ankle injury risk during the academic year.

Several studies have evaluated musculoskeletal injuries among preprofessional and professional dancers.[2–4 8 12 25–28] Some of these studies reported the incidence of ankle injuries which ranged between 17% and 53%.[2 7 26] Compared with these studies, our study's IP is relatively low, which may be partly explained by the difference in follow-up time. Several previous studies had

Table 2 Univariate analyses of potential risk factors for the occurrence of ankle injuries among dance students (total n=91 with number of legs=182)

Dance student characteristics	Non-injured ankles (no of legs=161)	Injured ankles (no of legs=21)	Univariate analyses OR (95% CI)	P value
Age (year) (SD)	19.2 (1.4)	19.2 (2.3)	1.03 (0.74 to 1.43)	0.86
Sex (male)	42 (26.1%)	12 (57.1%)	0.27 (0.09 to 0.75)	0.01
BMI (kg/m^2) (SD)*	21.2 (2.0)	21.4 (1.4)	1.05 (0.86 to 1.29)	0.61
Educational programme (BDE)†	61 (37.9%)	3 (14.3%)	0.27 (0.08 to 0.97)	0.045
Long-lasting ankle injury in the past year	4 (2.5%)	0 (0.0%)	n.a.	n.a.
Ankle range of motion (abnormal)‡	26 (16.1)	2 (9.5)	0.69 (0.14 to 3.38)	0.65
Ankle dorsal flexion (wall to toe distance in centimetres) (SD)§¶†	14.5 (2.6)	15.3 (3.0)	1.10 (0.91 to 1.34)	0.34

Presented in n (%), unless otherwise stated.
*Missing data from four dance students (eight legs).
†Reference category is the educational programme bachelors in dance.
‡Range of motion dichotomised into normal and abnormal (hypermobile and hypomobile range of motion), with a normal range of motion as the reference category.
§Measured with the weight-bearing lunge test.
¶Missing data from 4 dance students (8 legs).
BDE, bachelors in dance education; BMI, body mass index; ; n.a., not available.

a follow-up time of 5–10 years,[4 26 27] while we included two cohorts with a follow-up period of one academic year. As such, the incidence of injury expressed in hours of exposure seems a better measure to compare results. While some studies presented injury rates per 1000 dance exposure hours,[2 3 5] none specifically presented these rates for ankle injuries. We calculated the incidence rate of ankle injuries (n=23) per 1000 dance exposure hours based on the total group exposure and found an incidence rate of 0.24 (95% CI 0.14 to 0.34). Compared with general injury rates per 1000 dance exposure hours within the literature[2 3 5] (range between 1.2 and 1.9 injuries per 1000 dance exposure hours), our incidence rate was lower than the rates reported. This is expected because we focused only on ankle injuries and did not account for all dance injuries in the analyses.

Our results showed that the ankle injury IP varies greatly depending on the injury definition, ranging from 7.7% to 18.7%. This is consistent with previous research applying multiple injury definitions to all dance-related injuries.[14] Of note, there were almost twice as many time-loss injuries than medical attention injuries. The under-representation of medical attention injuries in a population of preprofessional dancers might be due to the fear of not being allowed to participate in classes, rehearsals or performances.[14 17 25 29] Conversely, confidential self-reporting allowed dancers to report injuries they otherwise might not have reported to the health team.[30] As with preprofessional dancers, similar beliefs of fear and avoidance also play a role in injury reporting among professional dancers. Vassallo *et al* investigated injury fear and injury reporting behaviours in 146 professional dancers in Australia. They found that more than 50% of dancers fear the consequences of sustaining a dance-related injury and that this stigma had delayed reporting the injury or seeking medical care.[31]

To gain insight into the number of dance injuries in different target populations, we recommend using standardised injury definitions. In addition, this may also contribute to facilitating the synthesis of evidence in future systematic reviews and meta-analyses.

Due to the prevalence of sustaining a musculoskeletal injury among preprofessional dancers, it is important to identify who sustains these injuries.[13] We found two significant independent variables associated with injury prevalence in our univariate analyses (sex and educational programme), but these variables were no longer significant in our multivariate analysis.

The relatively small population might explain this, as the follow-up period was only short term (12 months). In this time, we could only identify a small number of reported ankle injuries, and thus, fewer variables were entered into our regression analysis.[23 24] The selection of these variables was based on the existing literature. For example, it has been reported that bodyweight seems to be related to ankle injuries and that limited dorsiflexion has been observed with a higher risk of lower extremity injuries across athletes and dancers.[8 12 32 33] However, none of these factors was significantly associated with ankle injuries in our population. It remains difficult to compare our findings with the existing literature. Most previous studies investigating dance populations evaluated risk factors for injuries in general or injuries to a specific part of the body, for example, lower extremity. Still, they did not evaluate factors associated with ankle injuries specifically.[1 12 34] Studies that describe injury epidemiology and injury risk of general dance-related injuries in a population of preprofessionals show inconclusive findings. In

contrast to our results, a prospective cohort study among preprofessional reported a significantly higher number of injuries in male dancers compared with the female dancers.[7] In addition, several other prospective cohort studies did not show an association between sex,[3 12 35] educational programme[12 32] and injury risk. Therefore, the role of sex on the incidence of injuries remains largely unclear.

Although we found a rather low incidence of ankle injuries, we believe that the impact of ankle injuries should not be underestimated. The ankle is the most common type of injury among dancers and is already reported by up to 17% of dance students in the first year of their academic training.[3 25] Furthermore, it has been reported that out of all musculoskeletal injuries or diseases, ankle injuries among preprofessional dancers resulted in the longest absence from dance. In professional dancers, it was one of the main reasons for retirement.[8 10] After a dancer sustains an ankle sprain, more than 50% reported chronic ankle instability, which can significantly impact dance performance.[9] Therefore, first-year preprofessional dancers are a potentially suitable target group to prevent ankle injuries. The first step towards prevention is the recognition of who sustains ankle injuries. When the factors for ankle injuries can be determined in first-year pre-professional dancers, the dancers at risk for sustaining an ankle injury during their training can be recognised at an early stage.

Strengths and limitations

To our knowledge, this is the first study that focuses specifically on ankle injuries in contemporary preprofessional dancers in terms of incidence and factors associated with ankle injuries. Due to a high response rate during follow-up (95.8% completed three or more monthly questionnaires, 72.5% completed all 9 monthly questionnaires), we have likely included all ankle injuries that occurred during the academic year. As the questionnaires were completed monthly, recall bias was reduced. Moreover, we presented data based on four different injury definitions described in the literature and therefore present a clear overview of the incidence of ankle injuries within this population.[14 16] Nevertheless, a limitation that needs to be addressed is that we only included a follow-up of one academic year. As the incidence and the risk of an ankle injury might change throughout academic training, a follow-up period over all academic years might give a more representative overview of injuries. Another limitation is that in three out of four injury definitions, we used student reported outcomes. Most dance students lack medical expertise and, as such, diagnostic information may be misclassified. Additionally, symptoms or time-loss may be under-reported or exaggerated by the participants.

CONCLUSION

This study is the first study that provides an overview of ankle injuries among contemporary dance students and identifies ankle injury risk factors. Almost 20% of first-year dance students reported an ankle injury during one academic year, with more than 80% of these injuries leading to dance time loss. Males and students of the BDE seem to be at a lower risk of ankle injuries. Further research conducting studies with larger sample sizes, a more heterogeneous population (eg, different dance styles) and longer follow-up periods is deemed necessary to evaluate this type of injury, especially considering that ankle injuries are the most common injuries among (pre) professional dancers.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Ethical approval was given by the Medical Ethics Committee of the Erasmus MC University Medical Center Rotterdam, the Netherlands (MEC-2019–0163).

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