Dance load, well-being and injury in collegiate Irish and contemporary dancers: A prospective study

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Abstract

Objectives: Dance exposure and determinants of wellness in Irish dance (ID) and contemporary dance (CD) are under-investigated in pre-professional, collegiate cohorts. This study prospectively investigated these variables in ID and CD participants for one year.

Design: Prospective study.

Setting: University-level institutes of dance, United Kingdom (UK) and Ireland.

Participants: Fifty (ID=21, CD=29) full time students of dance at XXXX, (UK) and the XXXX, Ireland.

Main Outcome Measures: Weekly hours of dance, general health, sleep quality, injury defined as "any pain or injury that impacted upon their ability to dance".

Results: Dance exposure varied considerably for both genres across the year. CD participants danced for more hours weekly ($p<0.001$). Overall injury incidence (time-loss and non-time-loss) was 10.6 and 8.4 injuries per 1000 hours dancing for ID and CD groups respectively. 70.4% of injuries were non-time-loss. Better sleep ($p=0.007$) and general health ($p<0.001$) scores were negatively correlated with days lost/impacted by injury. CD participants reported a significantly higher dance exposure in the week prior to a time-loss injury than during the previous four weeks ($p=0.044$).

Conclusions: Dance exposure is erratic in these cohorts with dancers frequently performing when injured. Poor sleep, general health, and increased dance exposure may be associated with injury.

Key Words: Pre-professional dancers, pain, dance burden, health.

Introduction

Contemporary and Irish dancing (ID) have emerged as popular genres in the latter half of the twentieth century (Angioi et al., 2009b, Cahalan and O'Sullivan, 2013). Contemporary dance (CD) which developed from the female physical education programmes of the 1970s (Bonbright, 1999) fuses elements of ballet, modern dance and other influences (Angioi et al., 2009a). ID was reinvigorated in the 1990s by productions such as "Riverdance" which gained international appeal. Notwithstanding the many physical and psychological benefits of dance (Alpert, 2011), it has been shown that pre-professional dancers experience elevated levels of disablement due to pain, stress and impaired motion compared to other performer patient groups (White, Hoch and Hoch, 2018). Pre-professional dancers often progress their careers via university–level programmes, thus potentially encountering the difficulties faced by many students including homesickness and adjustment (Thurber and Walton, 2012), challenges to psychological wellbeing and cognitive affective strategies (Conley et al., 2014), as well as self-regulation of new found independence (Wibrowski, Matthews and Kitsantas, 2016). As aesthetic athletes, dancers may additionally experience higher levels of eating disorders and body-dissatisfaction than non-dance peers (Goodwin et al., 2014), maladaptive perfectionism (Stoeber, 2014), and substantial rates of injury (Baker et al., 2010, Ekegren, Quested and Brodrick, 2014).

Despite marked differences in choreography and technique, and a paucity of study in pre-professional cohorts, substantial injury rates have been recorded across numerous genres. A prospective study of pre-professional ballet and modern dancers over one academic year reported a prevalence of 86.2% (Lee et al., 2017). This compares to an injury prevalence of 82.1% in a one-year prospective study of pre-professional ID (Cahalan et al., 2016). However, a systematic review of pre-professional ballet and modern dancers has identified a

lack of consensus regarding the risk factors for injury in this group, due to a dearth of robust research in this area (Kenny, Whittaker and Emery, 2015). This review also highlighted that the risk factors most often investigated included anthropometric factors, lower limb joint range of motion, dance exposure and age. Therefore, although the importance of multi-component injury surveillance and screening programmes for dance are advocated, (Molnar and Esterson, 1997), existing programmes focus predominantly on the physical attributes and technique of the dancer, and injury history (Bronner and Bauer, 2018). Additional important considerations include cross-training, general health, wellbeing, and sleep (Cahalan et al., 2016). Data regarding cross-training are inconsistent (Fulton et al., 2014) and advice regarding exercise prescription is lacking (Carroll, 2014). Suboptimal sleep has been found to be associated with a higher rate of injury (Cahalan et al., 2016) and a lower resilience (Arbinaga, 2018) in dancers. Aspects of health and wellbeing including a greater number of general health complaints, low mood (Cahalan et al., 2015) and emotional exhaustion (Quested and Duda, 2011) are also associated with injury and burnout in this group.

The influence of dance exposure has been under-investigated in ID and CD. One recent study of pre-professional ballet and modern dancers has reported an association between high dance exposure and injury risk (Lee et al., 2017), and the potential benefits of load tapering and periodisation for dancers have previously been proposed (Wyon, 2010). However robust studies in ID and CD cohorts are lacking, and due to the unique nature of dance genres, it is unclear if the findings in other dance forms are directly applicable. The current study therefore prospectively investigated dance exposure (hours of dance activity), cross–training, sleep, general health and injury among pre-professional student dancers from ID and CD genres. It was hypothesised that sudden spikes in dance exposure, suboptimal sleep or general health would adversely impact upon injury incidence.

Methods

Participants

Participants for this pilot study were a sample of convenience based at institutions in the United Kingdom (Institution name redacted for peer review), and the Republic of Ireland (Institution name redacted for peer review). Inclusion criteria required participants to be full-time students of either CD or ID, to be 18 years of age or older with a good command of spoken and written English. Contemporary dancers (n=30) were drawn from both institutions; Irish dancers (n=27) were sourced solely from the (Institution name redacted for peer review), where the only full-time ID university program internationally is located. Admission to the dance programmes involved in this study included audition, and required extensive dance experience in the relevant genre. All participants identified either CD or ID as their principal dance genre, and the main focus of their dance studies. All participants provided written informed consent.

Study procedure

Baseline demographic, injury and dance history data were collected via an online questionnaire at the start of the study, as detailed elsewhere (Cahalan et al., 2018). All participants were then followed up each week for one year using a brief online questionnaire. Participants recorded the number of weekly hours of dance activity and cross-training where applicable. Weekly general health and sleep quality were measured on a Likert scale from 1-5 (1=Very good; 5=very poor) (Cahalan et al., 2016). Participants reported any injury sustained during the week, body part affected, diagnosis if known, duration of the problem, and how it impacted upon their ability to dance (able to dance fully, partially, or completely unable to dance). This approach was informed by the injury surveillance protocol used by the Trinity Laban Conservatoire of Music and Dance (Cahalan, Bargary and O'Sullivan, 2018). Injuries

recorded to the same anatomical site and side of the body on consecutive weeks were considered to be the same injury. A minimum of a four-week injury-free gap between reports of injury to the same anatomical location was required before an injury was considered to be a new injury. Injury was defined in this study as "any pain or injury that impacted upon their ability to dance". This broad definition was informed by findings that a strict time-loss definition of injury may understate the actual level of pain and injury experienced by dancers (Kenny et al., 2018). This approach additionally conforms to current recommendations regarding injury surveillance across a variety of sports (Clarsen, Myklebust and Bahr, 2012). Participants were further advised to disregard illnesses such as head colds. Weekly email reminders were sent to encourage compliance.

Statistical Analysis

Statistical analyses were completed using IBM SPSS version 24. Between genre comparisons of age, dance exposure (weekly hours of dance training), weekly hours of cross-training, and injury incidence were conducted using independent t-tests, or Mann-Whitney U tests as appropriate. Fisher's exact test was used to investigate differences in the sex composition of genres. Spearman's rho was used to investigate correlations between (a) the proportion of weeks in which sleep quality was rated very good/good and the number of days missed/impeded during injury, and (b) the proportion of weeks in which general health was rated very good/good and the number of days missed/impeded during injury. A further question of interest was whether dancers' dance exposure, sleep quality, or general health ratings were different in the week before an injury compared to the preceding four weeks. Mean dance exposure for the week prior to, and the four weeks prior to, any injury which resulted in at least one day lost to dancing, were compared (Saw et al., 2010) using Wilcoxon

signed ranks tests. Pearson's correlation coefficient (r) provided a measure of effect size for all tests (Field, 2005). Alpha was set at p=0.05.

Ethical Approval

Ethical approval was granted by the research ethics committees of both institutions.

Results

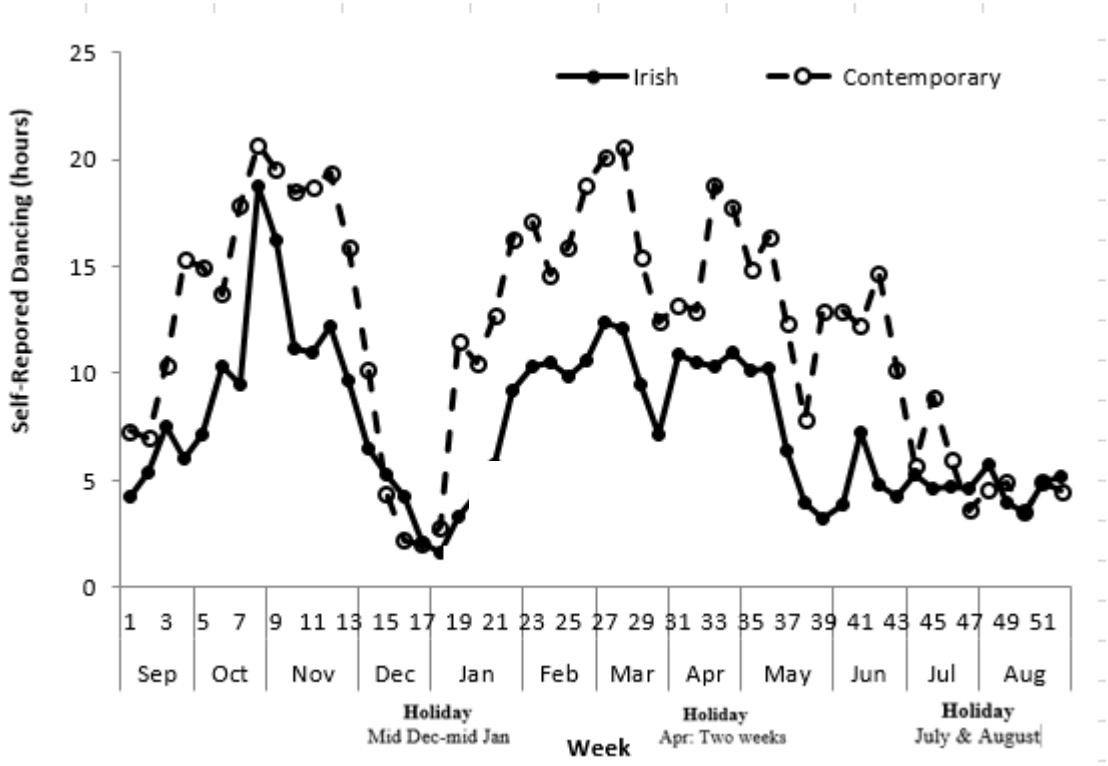
Of an initial cohort of 57 dancers (ID: n=27(47.4%), CD: n=30(52.6%)), only the data of those participants who completed at least 80% of the weekly follow-ups were considered. This resulted in a final study cohort of 50 participants (ID: n=21(42.0%), CD: n=29(58.0%)). Regarding these participants, data were provided for a mean of 50 weeks (range 46-52 weeks) and 48 weeks (range 42-52 weeks) for ID and CD participants respectively. There were no significant differences in age or sex between genres; the ID group had a mean (standard deviation (SD)) age of 21.5 (1.7) years (20 female, 1 male), while the CD group had a mean (SD) age of 21.0 (3.1) years (28 female, 1 male). There were no differences between the CD groups from the UK and Ireland in terms of sex (Fisher's exact test, $p = 0.436$), age ($z = -0.728$, $r = -0.14$, $p = 0.486$) or dance exposure ($z = -0.392$, $r = -0.07$, $p = 0.717$).

Dance exposure and cross-training activity

The mean (SD) number of weekly dance exposure was significantly greater ($t(48) = -4.588$, $r=0.62$, $p<0.001$) in the CD group at 12.17(3.23)hrs/wk compared to the ID group at 7.58(2.44)hrs/wk. There was no significant difference in the median (inter-quartile range (IQR)) weekly hours of cross-training engaged in by the ID (3,(1.8)) and CD participants (2.4, (1.85)), ($z = -0.384$, $r= -0.05$, $p=0.707$). Variation in mean dance exposure by both

groups over the calendar year (Figure 1) is indicative of an erratic schedule of dance activity in both genres.

Figure 1: Variation in self-reported weekly dance exposure for Irish and Contemporary dancers.



Injury

Over the year, injury impacted on the participants' ability to dance (either partially or fully) for a median of ten days (IQR:11) for the ID group and a median of nine days (IQR:25) for the CD group. There was no significant difference between the groups, (z= -0.562, r= -0.08, p=0.574). Regarding time-loss injuries only (participants fully unable to dance for at least one day), ID participants reported losing a median of five days (IQR:7) to injury over the year,

while CD participants lost a median of two days (IQR:7). As previously, there was no significant difference between the groups, ($z = -0.926$, $r= -0.13$, $p=0.354$). ID and CD participants additionally reported dancing (either partially or fully) despite injury on a median of three (IQR:3), and seven (IQR:17) days respectively. Again, the groups were not significantly different ($z= -1.611$, $r= -0.22$, $p= 0.107$). In percentage terms, 29.6% of all injuries resulted in time loss (ID: 31.8%; CD: 28.4%), indicating that participants mostly continued to dance injured.

The 21 ID participants reported a total of 88 injuries (mean number of injuries per dancer (SD): 4.2(2.5), and the 29 CD participants reported a total of 155 injuries (mean number of injuries per dancer (SD): 5.3(4.1). When injuries are defined as self-reported injury which may/may not have resulted in absence from dancing, ID participants reported an incidence of 10.6 injuries per 1000 hours dancing, compared to 8.4 injuries per 1000 hours dancing for CD participants. The time-loss incidence rate for participants was 3.4 injuries per 1000 hours of dancing was 3.4 and 2.4 injuries for ID and CD participants respectively.

The lower limb (knee, foot/ankle, thigh) and lower back were the body parts most commonly injured in both cohorts. Cause and diagnosis were unknown or unclear for a large proportion of participants from both genres. Where known, injury was commonly attributed to overuse or accident by both groups, and issues pertaining to muscle, joint and ligament were cited by both groups where diagnoses were known (Tables 1-3).

Table 1
Number and location of injuries reported by Irish and Contemporary dancers over the course of one year

Site	All Participants		Irish Dancers		Contemporary Dancers	
	N injuries	%	N injuries	%	N injuries	%
Knee	41	16.9	14	15.9	27	17.4
Foot/ankle	41	16.9	21	23.9	20	12.9
Thigh	24	9.9	10	11.4	14	9.0
Lower back	23	9.5	8	9.1	15	9.7
Groin	15	6.2	3	3.4	12	7.7
Shoulder	13	5.3	2	2.3	11	7.1
Neck	12	4.9	6	6.8	6	3.9
Shin	12	4.9	4	4.5	8	5.2
Upper back	11	4.5	4	4.5	7	4.5
Head	10	4.1	3	3.4	7	4.5
Buttocks	9	3.7	6	6.8	3	1.9
Calf	9	3.7	3	3.4	6	3.9
Toes	9	3.7	1	1.1	8	5.2
Mid back	6	2.5	1	1.1	5	3.2
Chest	5	2.1	1	1.1	4	2.6
Ribs	3	1.2	1	1.1	2	1.3
Total	243		88		155	

Table 2
Perceived causes of injuries reported by Irish and Contemporary dancers over the course of a year

Cause	All		Irish		Contemporary	
	N injuries	%	N injuries	%	N injuries	%
Unsure	63	26.1	27	31.0	36	23.4
Overuse	48	19.9	17	19.5	31	20.1
Accident	26	10.8	8	9.2	18	11.7
Choreography/Technique	24	10.0	3	3.4	21	13.6
Previous injury	17	7.1	6	6.9	11	7.1
Tightness	13	5.4	4	4.6	9	5.8
Other activity	12	5.0	5	5.7	7	4.5
DOMS	8	3.3	5	5.7	3	1.9
Posture	6	2.5	3	3.4	3	1.9
Weakness	4	1.7	0	0.0	4	2.6
Structure/biomechanics	4	1.7	0	0.0	4	2.6
Fatigue	4	1.7	1	1.1	3	1.9
Flooring/Environment	3	1.2	1	1.1	2	1.3
Growth	3	1.2	1	1.1	2	1.3
Inadequate warm up	2	0.8	2	2.3	0	0.0
Other (e.g. vaccination)	4	1.7	4	4.6	0	0.0
Total	241		87		154	

DOMS: Delayed onset muscle soreness

Table 3
Diagnoses of injuries self-reported by Irish and Contemporary dancers over the course of a year

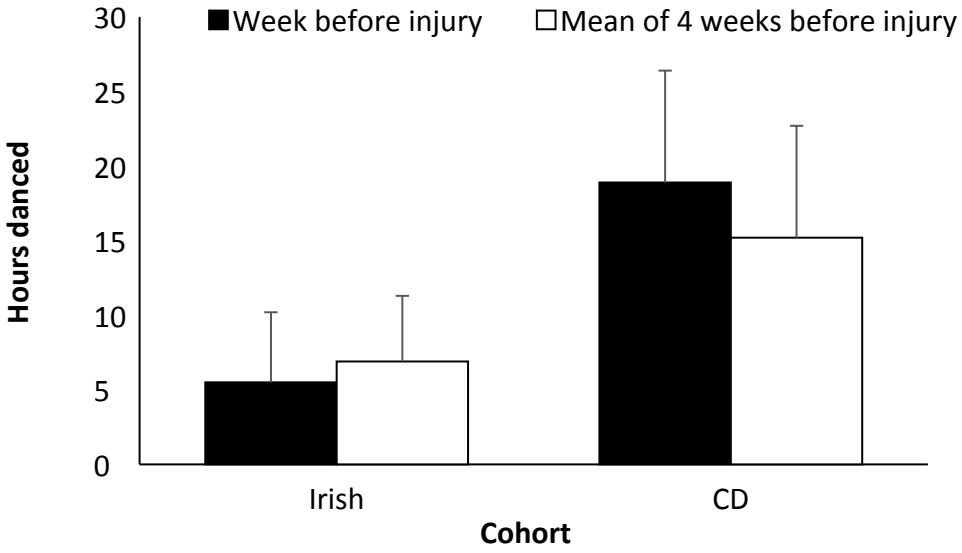
Diagnosis	All		Irish		Contemporary	
	N injuries	%	N injuries	%	N injuries	%
Unclear/unknown	139	57.7	50	57.5	89	57.8
Muscle	51	21.2	16	18.4	35	22.7
Joint	11	4.6	5	5.7	6	3.9
Sprain/Ligament	10	4.1	3	3.4	7	4.5
Nerve	7	2.9	3	3.4	4	2.6
Shin splints	5	2.1	1	1.1	4	2.6
Impingement	4	1.7	3	3.4	1	0.6
Tendinopathy	3	1.2	1	1.1	2	1.3
Inflammation	3	1.2	0	0.0	3	1.9
Infection	3	1.2	3	3.4	0	0.0
WAD/Concussion	3	1.2	1	1.1	2	1.3
Other	2	0.8	1	1.1	1	0.6
Total	241		87		154	

WAD: Whiplash Associated Disorder. Other: Meniscus, Fracture, Fasciitis, Bursitis.

Dance exposure and injury

Mean dance exposure for the week prior to, and the four weeks prior to, any injury which resulted in at least one day lost to dancing, were compared. In the ID group, there was no difference between the hours danced in the week before injury (mean (SD):5.5(4.7)), and the mean weekly hours danced over the four weeks before injury, (mean (SD):6.9(4.4)), ($z = -0.55$, $r= -0.10$, $p= 0.582$). In contrast, CD participants who suffered a time-loss injury reported significantly more hours of dancing in the week prior to the injury (mean (SD): 18.9(7.5)) than over the four weeks preceding injury (mean (SD): 15.2(7.5)), ($z= -2.02$, $r= -0.34$, $p= 0.044$) (Figure 2). Interestingly, mean dance exposure typically reverted back to normal volumes after the injury, which is consistent with the large number of minor injuries reported by participants.

Figure 2: Mean (SD) dance exposure in the week prior to, and the four weeks prior to time-loss injury.



Sleep, general health and injury

A weak negative relationship was found between the percentage of weeks during which sleep was rated good or very good and the number of days that a dancer reported being unable to dance, or impeded in his/her dancing ($r_s = -0.375$, $p= 0.007$). Dancers who reported good or very good quality sleep more often were less likely to report interruption to full dance participation. Similarly, there was a moderate negative relationship between the percentage of weeks during which general health was rated very good or good and the number of days on which a dancer was unable to dance fully ($r_s = -0.516$, $p< 0.001$). That is, individuals who rated their general health as good or very good more often reported fewer days lost/impeded due to injury over the course of the year.

The median scores for sleep and general health for those participants who suffered at least one day's absence from dance due to injury are illustrated in Table 4. There were no significant differences in the sleep quality in the week before injury and the four weeks preceding the injury in either genre (ID: z= -0.458, r= -0.11, p=0.647; CD: z= -0.00, r= 0.00, p=1.00.) Similarly, there were no significant differences in general health in the week before injury and the four weeks preceding the injury in either group (ID: z= -0.716, r = -0.19, p=0.474; CD: z= -0.512, r= -0.17, p=0.609). Scores for both sleep quality and general health stayed at similar levels in the week following injury for both groups.

Table 4
Median Sleep Quality and General Health during and one week before injury, one week post injury and four weeks before injury

	Genre	Week of injury	Week before injury	Week after injury	Four weeks before injury
Sleep Quality	Irish	3	3	2	2.5
	Contemporary	3	2.5	2	2.6
	All	3	2	2	2.5
General Health	Irish	2	2	2	2.3
	Contemporary	3	2	3	2.4
	All	2	2	2	2.3

Likert Scale: 1=Very good, 2 = good, 3 = neither good not poor, 4 = poor, 5 = very poor

Discussion

This study prospectively investigated the weekly hours of dance, cross-training, general health, sleep, and injury patterns of cohorts of CD and ID participants. Findings suggest that both cohorts engaged in an erratic calendar of dance exposure, with sudden spikes in hours danced associated with increased injury in CD participants in subsequent weeks. Better self-

reported sleep and general health was associated with lower levels of injury in both groups. Cross-training appears to be underutilised in both cohorts. Levels of injury are substantial in both cohorts with the lower limb and back most commonly affected, however most injuries did not result in absence from dance.

Dance exposure

Comparing dance load in various pre-professional cohorts is challenging due to a lack of standardisation in the measurement of dance exposure in the literature (Caine et al., 2015). Much of the research pertaining to dance exposure relates to ballet, with levels varying from approximately 20 (Gamboa et al., 2008) to 30 hrs/wk (Ekegren, Quested and Brodrick, 2014). Of note is that these studies pertain to a training or academic year only, in comparison to a calendar year as in this study. Also, it is unclear whether the relatively higher level of dance exposure in pre-professional ballet includes technique classes which would be more numerous than in CD or ID.

Dance exposure in the current study was characterised by erratic spikes and dips in hours of dancing each week in both genres. Bearing in mind the collegiate nature of the cohorts, the low levels of activity in the summer months and during holiday periods in December and spring were to be expected. There were steep increases in weekly dance exposure at the start of the academic year in September for both groups which tail off over the semester. There were no extended periods where hours of dance activity remained constant, nor were there any obvious opportunities for periodisation for either group. This may suggest that participants were unable to gradually acclimatise and increase hours of dance, or to maintain hours of dance for prolonged periods. CD participants engaged in dance activity for statistically more time each week than the ID group. This is possibly due to the nature of both

genres, with ID being more ballistic and explosive, with typical routines lasting no longer than a minute or two in duration. CD in contrast may contain alternating periods of maximal and sub-maximal activity (Wyon, 2007), and may therefore be potentially less fatiguing than ID. Of note was the fact that the CD group experienced a significant increase in hours of dance in the week prior to an injury. This may simply be related to the overall greater volume of dancing undertaken by these participants, or may indicate a vulnerability to sudden increases in dance volume.

Spikes in injury rates on return to dance practice after summer vacation have been observed in liberal arts dance students, possibly related to increased dance activity following a period of low dance exposure (DiPasquale et al., 2015). Extensive literature in many sporting populations has identified that optimal training exposure is required to promote positive physical adaptation, while excessive, acute training exposure is associated with maladaptation, overtraining and eventual injury (Windt and Gabbett, 2017). Although the benefits of periodisation are widely recognised in sports (Soligard et al., 2016), they may be under-recognised in dance. Furthermore, the often sporadic timetable of dance performances, auditions, rehearsals and exams may not allow for the seasonality associated with many sports, and pose a further challenge. Clinicians have a key role in the education of dance professionals about strategies regarding periodisation and load management, to optimise dancer longevity, health and performance.

Cross-training activity

Both groups undertook relatively little weekly cross-training at approximately 3 and 2.4 hours for the ID and CD groups respectively. In a previous cohort of 166 professional Irish dancers, 25.3% performed no cross-training whatsoever (Cahalan and O'Sullivan, 2013).

Cross-training was similarly eschewed by collegiate modern dancers who were found to have inadequate upper body strength to meet the demands of their dance activity (Sides, Ambegaonkar and Caswell, 2009). It has been proposed in the literature that some dancers will avoid cross-training, believing it to adversely affect dance ability (Miller and Miller III, 2017). However, cross-training for pre-professional dancers has been advocated to prepare them for a professional career (Bronner et al., 2016). In this study, levels of cross-training were low and remained relatively constant throughout the year regardless of hours danced and/or injury. Given the diverse technical and choreographical demands of ID and CD, appropriate cross-training regimens for the genres in this study may be markedly dissimilar. It is incumbent upon clinicians to familiarise themselves with the varying technical demands of specific dance genres to facilitate appropriate cross-training both in prehabilitation and post-injury rehabilitation interventions.

Injury

Notwithstanding the acknowledged choreographical differences between the genres, there was much similarity in the pattern of injuries reported. The lower limb and lower back were the anatomical areas most commonly affected, in line with most similar research in this area (Cahalan et al., 2016, Yau et al., 2017). Similarly, diagnoses (where known) reflected previous findings indicating that injuries to muscle, joints and ligaments are pervasive (Malkogeorgos et al., 2011). The large proportion of injuries with an "Unclear/Unknown" diagnosis indicates that many injuries were never reviewed by a medical professional. It is unknown whether this was because the dancers considered the injury to be benign, felt they could manage it themselves, or chose not to, or were unable to, attend a medical professional. The injury rate was only marginally higher for the ID than the CD group. The broad definition of injury in this study to include events which did impact upon their dancing, but

did not necessarily lead to complete cessation, illustrated that these participants often continued to dance while injured.

In this study, the rate of injury using this broad definition was 10.6 injuries per 1000 hours dancing for the ID group, compared to 8.4 injuries per 1000 hours dancing for CD group. When only time-loss injuries were considered, these figures were adjusted downwards to 3.4 injuries and 2.4 injuries per 1000 hours of dancing for the ID and CD groups respectively. A similar prospective study of 66 pre-professional ballet and modern dancers (Lee et al., 2017) reported an injury rate of 2.27 per 1000 hours of dance exposure. However dance exposure hours in the Lee study were calculated based on the weekly academic timetable of dancers, and may not reflect the actual hours of dance undertaken by participants, or dance exposure outside of the academic day or calendar.

A recent study involving pre-professional ballet and contemporary dancers reported that, depending on the definition of injury used, injury prevalence varied from 9.4% (time-loss) and 82.4% (any complaint), and incidence of injuries per 1,000 hours of dance ranged from 0.1 (time-loss) and 4.9 (any complaint) (Kenny et al., 2018). Thus, a purely time-loss definition of injury likely underestimates the actual incidence of injury in dance. This may indicate the perceived ability of many dancers to manage their injuries themselves, an unwillingness or inability to access professional medical help, or reflect the accepted subculture of injury concealment within dance (McEwen and Young, 2011). Furthermore, some dancers are reticent to cease dancing when injured due to a maladaptive passion for dance which exceeds the impact of the injury, often leading to chronicity (Markula, 2015). In this study, the main perceived cause of injury by participants in both genres was “unknown” which may indicate non-traumatic pain-related mechanisms, which may require a different

management strategy to a clearly identifiable traumatic injury event. This may illustrate the complex interplay of pain and injury, which are markedly different concepts, but have been shown to be used and interpreted interchangeably by dancers (Thomas and Tarr, 2009). Clinicians must be aware of these considerations when dealing with dancers, and appreciate the complexity of biopsychosocial factors that impact upon both injury presentation and management.

Sleep and general health

Participants who more often rated their sleep and/or general health as good or very good, had fewer days lost/impeded due to injury over the year. These findings replicate earlier work in elite adult Irish dancers (Cahalan et al., 2015, Cahalan et al., 2016). In athletic cohorts, the adverse impact of disordered sleep on performance, and cognitive and physiological responses to exercise are recognised (Fullagar et al., 2015). Appropriate sleep has been identified as having a protective effect against overuse injury in dancers by improving motor control (Batson, 2007), with poor sleep associated with inflammatory disease risk and all-cause mortality (Irwin, Olmstead and Carroll, 2016). However further study of sleep in dancers is warranted. Research into the health of dancers is overwhelmingly focussed on injury, thereby potentially neglecting the impact of non-injury related illness. In athletic groups, it has been reported that the immune system may become temporarily weakened following prolonged endurance exercise, thereby increasing the prevalence of cardio-respiratory complaints, and adversely affecting performance (Walsh et al., 2011). Additionally, participants are likely to have been influenced by their current injury status when reporting their weekly general health. However it is noteworthy that the median values reported by these participants typically reflected good or neutral sleep and general health, and may indicate that this group generally experienced good health and sleep.

Limitations

The number of participants in this study is relatively small and data are largely self-reported, thereby open to interpretation and error. The unique characteristics of ID and CD may not be adequately explored by the factors investigated in this study. The measurement tools used for sleep and general health are relatively crude, and data regarding previous cross-training activity were not collected. The use of a four-week gap to categorise an event as a new injury was arbitrarily decided based on the clinical experience of the investigating team. However this may not accurately reflect the actual reality regarding injury recurrence and should be cautiously interpreted. Finally, a more expansive definition of training load combining an internal measure of exercise intensity such as rate of perceived exertion, and an external measure of activity such as hours dancing, would be preferable to hours of dance alone (Halson, 2014).

Conclusion

Both groups engaged in an erratic calendar of dance activity with sharp spikes and dips exhibited. Episodes of increased dance exposure were associated with injury in subsequent weeks for CD participants. Similarly, there was a correlation between both better health and better sleep, and reduced time lost to injury across both groups, although this requires further exploration. Clinicians must consider genre specific technical demands, and be mindful of the plethora of biopsychosocial factors that inform the dancer experience of injury when managing this group. Finally, consensus is required on a definition of injury that accurately reports incidence rates in these dancers.

Conflicts of interest

The authors have no conflict of interest to declare.

References

Alpert, P. T., (2011) 'The health benefits of dance', *Home Health Care Management & Practice*, *23*(2), 155-157. https://doi.org/10.1177/1084822310384689.

Angioi, M., Metsios, G., Koutedakis, Y. and Wyon, M. A., (2009a) 'Fitness in contemporary dance: a systematic review', *International Journal of SportsMedicine*, *30*(07), 475-484. DOI 10.1055/s-0029-1202821.

Angioi, M., Metsios, G. S., Twitchett, E., Koutedakis, Y. and Wyon, M., (2009b) 'Association between selected physical fitness parameters and aesthetic competence in contemporary dancers', *Journal of Dance Medicine & Science*, *13*(4), 115-123.

Arbinaga, F., (2018) 'Self-Reported Perceptions of Sleep Quality and Resilience Among Dance Students', *Perceptual and Motor Skills*, *125*(2), 351-368. 10.1177/0031512518757352.

Baker, J., Scott, D., Katherine Watkins, M., Keegan-Turcotte, S. and Wyon, M., (2010) 'Self-reported and reported injury patterns in contemporary dance students', *Age*, *25*(1), 10-15.

Batson, G., (2007) 'Revisiting overuse injuries in dance in view of motor learning and somatic models of distributed practice', *Journal of Dance Medicine & Science*, *11*(3), 70-75.

Bonbright, J. M., (1999) 'Dance education 1999: Status, challenges, and recommendations', *Arts Education Policy Review*, *101*(1), 33-39. https://doi.org/10.1080/10632919909600234.

Bronner, S. and Bauer, N. G., (2018) 'Risk factors for musculoskeletal injury in elite pre-professional modern dancers: A prospective cohort prognostic study', *Physical Therapy in Sport*, *31*, 42-51. https://doi.org/10.1016/j.ptsp.2018.01.008.

Bronner, S., Codman, E., Hash-Campbell, D. and Ojofeitimi, S., (2016) 'Differences in preseason aerobic fitness screening in professional and pre-professional modern dancers', *Journal of Dance Medicine & Science*, *20*(1), 11-22. https://doi.org/10.12678/1089-313X.20.1.11

Cahalan, R., Bargary, N. and O'Sullivan, K., (2018) 'Pain and Injury in Elite Adolescent Irish Dancers: A Cross-Sectional Study', *Journal of Dance Medicine & Science*, *22*(2), 91-99. https://doi.org/10.12678/1089-313X.22.2.91.

Cahalan, R., Comber L, Gaire D, Quin E, Redding E, Ni Bhriain O, and O'Sullivan, K., (2018) ' Biopsychosocial characteristics of contemporary and Irish university-level student dancers: A pilot study', *Journal of Dance Medicine & Science*, In Print.

Cahalan, R. and O'Sullivan, K., (2013) 'Injury in professional Irish dancers', *Journal of Dance Medicine & Science*, *17*(4), 150-158.

Cahalan, R., O'Sullivan, K., Purtill, H., Bargary, N., Bhriain, O. N. and O'Sullivan, P., (2016) 'Inability to perform due to musculoskeletal pain and injury in elite adult Irish dancers: a prospective investigation of contributing factors', *Scandinavian Journal of Medicine & Science in Sports*, *26*(6), 694-702. https://doi.org/10.1016/j.physio.2015.03.355.

Cahalan, R., Purtill, H., O'Sullivan, P. and O'Sullivan, K., (2015) 'A cross-sectional study of elite adult irish dancers: biopsychosocial traits, pain, and injury', *Journal of Dance Medicine & Science*, *19*(1), 31-43.

Caine, D., Goodwin, B. J., Caine, C. G. and Bergeron, G., (2015) 'Epidemiological review of injury in pre-professional ballet dancers', *Journal of Dance Medicine & Science*, *19*(4), 140-148. https://doi.org/10.12678/1089-313X.19.4.140.

Carroll, M. (2014) *Cross-training for dancers: does participation in other physical activities affect rates of dance injury?*California State University, Northridge, available: http://scholarworks.csun.edu/handle/10211.3/123344 [accessed 4/6/2018].

Clarsen, B., Myklebust, G. and Bahr, R., (2012) 'Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire', *British Journal of Sports Medicine*, *47*(8):495-502. doi: 10.1136/bjsports-2012-091524

Conley, C. S., Kirsch, A. C., Dickson, D. A. and Bryant, F. B., (2014) 'Negotiating the transition to college: Developmental trajectories and gender differences in psychological functioning, cognitive-affective strategies, and social well-being', *Emerging Adulthood*, *2*(3), 195-210. https://doi.org/10.1177%2F2167696814521808.

DiPasquale, S., Becker, N., Green, S. and Sauers, K., (2015) 'Self-reported injury and management in a liberal arts college dance department', *Medical Problems of Performing Artists*, *30*(4), 224-230.

Ekegren, C. L., Quested, R. and Brodrick, A., (2014) 'Injuries in pre-professional ballet dancers: Incidence, characteristics and consequences', *Journal of Science and Medicine in Sport*, *17*(3), 271-275. 10.1016/j.jsams.2013.07.013.

Field, A. (2005) *Exploratory factor analysis*, London, United Kindom.

Fullagar, H. H., Skorski, S., Duffield, R., Hammes, D., Coutts, A. J. and Meyer, T., (2015) 'Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and

cognitive responses to exercise', *Sports Medicine*, *45*(2), 161-186. https://doi.org/10.1007/s40279-014-0260-0.

Fulton, J., Burgi, C., Canizares, R. C., Sheets, C. and Butler, R. J., (2014) 'Injuries presenting to a walk-in clinic at a summer dance intensive program: a three-year retrospective data analysis', *Journal of Dance Medicine & Science*, *18*(3), 131-135.

Gamboa, J. M., Roberts, L. A., Maring, J. and Fergus, A., (2008) 'Injury patterns in elite preprofessional ballet dancers and the utility of screening programs to identify risk characteristics', *Journal of Orthopaedic & Sports Physical Therapy*, *38*(3), 126-136. DOI: 10.2519/jospt.2008.2390

Goodwin, H., Arcelus, J., Marshall, S., Wicks, S. and Meyer, C., (2014) 'Critical comments concerning shape and weight: associations with eating psychopathology among full-time dance students', *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*, *19*(1), 115-118. 10.1007/s40519-013-0075-2.

Halson, S. L., (2014) 'Monitoring training load to understand fatigue in athletes', *Sports Medicine*, *44*(2), 139-147. https://doi.org/10.1007/s4027.

Irwin, M. R., Olmstead, R. and Carroll, J. E., (2016) 'Sleep disturbance, sleep duration, and inflammation: a systematic review and meta-analysis of cohort studies and experimental sleep deprivation', *Biological Psychiatry*, *80*(1), 40-52. https://doi.org/10.1016/j.biopsych.2015.05.014.

Kenny, S. J., Palacios-Derflingher, L., Whittaker, J. L. and Emery, C. A., (2018) 'The Influence of Injury Definition on Injury Burden in Preprofessional Ballet and Contemporary Dancers', *journal of Orthopaedic & Sports Physical Therapy*, *48*(3), 185-193. 10.2519/jospt.2018.7542.

Kenny, S. J., Whittaker, J. L. and Emery, C. A., (2015) 'Risk factors for musculoskeletal injury in preprofessional dancers: a systematic review', *British Journal of Sports Medicine*, 50, 997-1003. http://dx.doi.org/10.1136/bjsports-2015-095121.

Lee, L., Reid, D., Cadwell, J. and Palmer, P., (2017) 'Injury incidence, dance exposure and the use of the movement competency screen (MCS) to identify variables associated with injury in full-time pre-professional dancers', *International Journal of Sports Physical Therapy*, *12*(3), 352.

Malkogeorgos, A., Mavrovouniotis, F., Zaggelidis, G. and Ciucurel, C., (2011) 'Common dance related musculoskeletal injuries', *Journal of Physical Education and Sport*, *11*(3), 259.

Markula, P., (2015) '(Im) Mobile bodies: Contemporary semi-professional dancers' experiences with injuries', *International Review for the Sociology of Sport*, *50*(7), 840-864. https://doi.org/10.1177%2F1012690213495745.

McEwen, K. and Young, K., (2011) 'Ballet and pain: reflections on a risk-dance culture', *Qualitative Research in Sport, Exercise and Health*, *3*(2), 152-173. https://doi.org/10.1080/2159676X.2011.572181.

Miller, L. and Miller III, F. L., (2017) 'A Comparative Analysis of the Fitness of Collegiate Dancers as compared to Collegiate Volleyball and Softball Players', *American Journal of Undergraduate Research*, *14*(1), 11-16.

Molnar, M. and Esterson, J., (1997) 'Screening students in a pre-professional ballet school', *Journal of Dance Medicine & Science*, *1*(3), 118-121.

Quested, E. and Duda, J. L., (2011) 'Antecedents of burnout among elite dancers: A longitudinal test of basic needs theory', *Psychology of Sport and Exercise*, *12*(2), 159-167. https://doi.org/10.1016/j.psychsport.2010.09.003.

Saw, R., Dennis, R. J., Bentley, D. and Farhart, P., (2010) 'Throwing workload and injury risk in elite cricketers', *British Journal of Sports Medicine*, 45(10), 805-808. http://dx.doi.org/10.1136/bjsm.2009.061309.

Sides, S. N., Ambegaonkar, J. P. and Caswell, S. V., (2009) 'High incidence of shoulder injuries in collegiate modern dance students', *Athletic Therapy Today*, *14*(4), 43-46. https://doi.org/10.1123/att.14.4.43.

Soligard, T., Schwellnus, M., Alonso, J.-M., Bahr, R., Clarsen, B., Dijkstra, H. P., Gabbett, T., Gleeson, M., Hägglund, M. and Hutchinson, M. R., (2016) 'How much is too much?(Part 1) International Olympic Committee consensus statement on load in sport and risk of injury', *British Journal of Sports Medicine*, *50*(17), 1030-1041. http://dx.doi.org/10.1136/bjsports-2016-096581.

Stoeber, J., (2014) 'Perfectionism in sport and dance: A double-edged sword', *International Journal of Sport Psychology*, *45*(4), 385-394. doi: 10.7352/IJSP 2014.45.385.

Thomas, H. and Tarr, J., (2009) 'Dancers' perceptions of pain and injury: positive and negative effects', *Journal of Dance Medicine & Science*, *13*(2), 51-59.

Thurber, C. A. and Walton, E. A., (2012) 'Homesickness and adjustment in university students', *Journal of American College Health*, *60*(5), 415-419. https://doi.org/10.1080/07448481.2012.673520.

Walsh, N. P., Gleeson, M., Shephard, R. J., Gleeson, M., Woods, J. A., Bishop, N., Fleshner, M., Green, C., Pedersen, B. K. and Hoffman-Goete, L., (2011) 'Position statement part one: immune function and exercise', *Exercise Immunology Review*, *17*, 6-63. https://dspace.lboro.ac.uk/2134/10584.

White, H. M., Hoch, J. M. and Hoch, M. C., (2018) 'Health-Related Quality of Life in University Dance Students', *Medical Problems of Performing Artists*, *33*(1), 14-19. https://sci-hub.tw/https://doi.org/10.21091/mppa.2018.1004

Wibrowski, C. R., Matthews, W. K. and Kitsantas, A., (2016) 'The Role of a Skills Learning Support Program on First-Generation College Students' Self-Regulation, Motivation, and Academic Achievement: A Longitudinal Study', *Journal of College Student Retention: Research, Theory & Practice*, *19*(3), 317-332. https://doi.org/10.1177%2F1521025116629152.

Windt, J. and Gabbett, T. J., (2017) 'How do training and competition workloads relate to injury? The workload—injury aetiology model', *BritishJjournal of Sports Medicine*, *51*(5), 428-435. http://dx.doi.org/10.1136/bjsports-2016-096040.

Wyon, M., (2010) 'Preparing to perform periodization and dance', *Journal of Dance Medicine & Science*, *14*(2), 67-72.

Wyon, M. (2007) 'Tesing the aesthetic athlete: Contemporary dance and classical ballet dancers' in *Sport and Exercise Physiology Testing Guidelines: The British Association of Sport and Exercise Sciences Guide*, London: Routledge, 242-262.

Yau, R. K., Golightly, Y. M., Richardson, D. B., Runfola, C. D., Waller, A. E. and Marshall, S. W., (2017) 'Potential Predictors of Injury Among Pre-Professional Ballet and Contemporary Dancers', *Journal of Dance Medicine & Science*, *21*(2), 53-63. doi: 10.12678/1089-313X.21.2.53.