Weekly injury rates within semesters of a three-year tertiary dance program, and prospective training monitoring across one semester of training: A longitudinal study

Abstract

Dance research should consider time points within a season that may be associated with injury, and report on weekly dance training loads. This information will further understanding of dance exposure and guide future injury reduction programs. The current study aimed to analyse injuries within each semester and participant, monitor load, mood and stress within one semester, and calculate compliance with monitoring in a pre-professional tertiary dance training cohort part way through their training. The tertiary dance training program that participants are drawn from is a six-semester, three-year undergraduate course, training in ballet and contemporary dance. A better understanding of injury in dance may further refine load management and injury prevention strategies specific to a dance context. Fourteen tertiary dance students training in ballet and contemporary dance consented to participate. Injury data were extracted from onsite physiotherapy notes; a medical attention injury definition was used. Weekly injury rate ratios (number of injuries in the week of interest relative to the other 13 weeks in the semester) within each 14-week semester were calculated. Subsequent injuries for weeks with significant injuries were considered for within-participant analysis. Participants completed ratings of perceived exertion (RPE) daily and collected weekly (CR-10 scale), and mood (via the Brunel Mood Scale) and stress (via the Perceived Stress Scale-10) questionnaires at weeks 1,4,8,10,12 and 14 across one semester. 95% confidence intervals (CI) were calculated, inferring a P-value $\geq$ 0.05. The mean and SD were reported, with patterns visually observed from line graphs to determine increases, decreases, and spikes for mood, training load (RPE x minutes of training), and stress. Injuries were significantly increased for Week 5, Semester 1 (5.78; 95%CI: 1.55, 18.48); Week 2, Semester 2 (7.62; 95%CI: 1.96, 26.30); and Week 1, Semester 3 (4.88; 95%CI: 1.05, 17.81), and 4 (13; 95%CI: 1.35, 124.90). Spikes in load coincided with injury spikes, as observed visually on a line graph. Within a tertiary dance program, certain weeks in proximity to a change in training schedule had increased injury. Within-participant injury patterns, and trends concerning mood, stress, and load were observed. The low sample size and poor compliance may have led to an over and underestimation of results. The authors suggest that healthcare practitioners should work closely with dancers and dance educators to aid compliance with monitoring

practices to aid dance educators in understanding how dancers are adapting to training. Applying training principles in response to monitoring, specifically to return to dance after a holiday period, may aid in reducing injuries at this time shown to be significant. Future research should investigate end-user perceptions of training monitoring and the effectiveness of load management or periodisation of dance training as an injury reduction strategy.

Keywords: dance, ballet, contemporary dance, injury prevention, training load, training load monitoring, periodisation

Introduction

Injury surveillance should be established across all sports (Soligard et al., 2016), to understand the injury problem in the specific context, and would benefit from considering the temporal pattern of injury (Finch, 2006). Most injury surveillance research in dance reports injury monthly when investigating the timing of injury (Fuller, Moyle, Hunt, and Minett, 2020). It may be beneficial to narrow the denominator to weekly to refine further when injuries occur to direct investigation towards injury reduction strategies. In their systematic review with meta-analysis, Armstrong and Relph (2018) identified that future research in dance should consider time points within a season that may be associated with injury and report on weekly dance training loads. A focus group investigation of medical staff, artistic staff and dancers of a professional ballet company revealed consistent mention of the relationship of load and load capacity as a reason for injuries in dance, as well as an injury prevention measure (Bolling, van Rijn, Pasman, van Mechelen, and Stubbe, 2021). One study (Boeding, Visser, Meuffels, and de Vos, 2019) has shown a relationship (95% confidence interval [CI]: 129, 1,479) between weekly training load and symptoms of overuse injury in professional dance, with higher training load values related to increased symptoms. A better understanding of weekly injury data in dance may further refine load management and injury prevention guidelines (Soligard, Schwellnus, Alonso, Bahr et al., 2016) specific to a dance context.

Scientific monitoring of athletes or dancers is recommended for successful load management (Soligard et al., 2016) to know how the individual is responding to training, and for the monitoring to be successful, there needs to be sufficient uptake (Finch, 2006). However, load monitoring research is in its infancy in dance (Boeding, Visser, Meuffels, and de Vos, 2019; da Silva et al., 2015; Jeffries, Wallace, and Coutts, 2017; Jeffries et al., 2020; Liederbach, Glaim, and Nicholas, 1994). Karreman, Keizer-Hulsebosch, and

Stubbe (2019) investigated an online dance-health surveillance system in a professional ballet company. The thematic analysis of focus group interviews of dancers who participated in the biweekly surveillance revealed a preference to complete monitoring every week to provide more insight into injury and workload. They also suggested adding more items to the questionnaire regarding workload, mental health, sleep, rest and nutrition to give a more holistic view of dancer health. Compliance (McKay and Verhagen, 2016) in this study was 93% to complete biweekly questionnaires over two months. Two other studies have examined dance student compliance with completing questionnaires on self-reported injuries over one training year, with 99% (Kenny, Palacios-Derflinger, Whittaker, and Emery, 2018) and 80% (van Winden et al., 2019) weekly and monthly compliance reported, respectively.

Previous injury and the number of previous injuries have been reported to be risk factors for future injury in pre-professional ballet and modern dance students (Kenny et al., 2016) and ballet dancers (Biernacki et al., 2018), respectively. Hence, investigation of the within-person dependency of subsequent injuries sustained by an individual is warranted (Finch and Cook, 2014; Toohey et al., 2018). Clinicians may consider "the time between injury occurrences, the biomechanical relationships between body segments specific to the demands of the sport, the established training workload following a previous injury, and residual deficits or changes in technique related to a previous injury" (Toohey et al., 2019, p.4) amongst other factors when considering the risk of subsequent injury. An updated subsequent injury categorisation model has been developed with a clinical sub-categorisation when categorising subsequent injuries, taking into account clinical reasoning (Toohey et al., 2018; Toohey et al., 2019). Clinical practice and expertise can influence the generation of new research questions (Paez, 2018), and although it is suggested that subjective clinical reasoning should be considered

with caution, clinical insights can also inform the understanding of injury (Toohey et al., 2019).

This study aims to build on a previous study (Fuller, Moyle & Minett, 2020) that reported retrospectively on injury incidence per semester, percentage of injuries per anatomical location and affected tissue, subsequent injuries, and median time to injury for each semester for a separate cohort of participants that had completed their tertiary dance training. This study does not intend to replicate this analysis. However, it aims to analyse injuries within each semester and participant, monitor load, mood and stress within one semester, and calculate compliance with monitoring in a pre-professional tertiary dance training cohort part way through their training. Identifying weeks with greater injury rates, analysis of within-participant injuries at these times of greater group injury susceptibility, and calculations of compliance with monitoring will guide future research towards load management injury reduction strategies in dance.

Materials and Methods

Study design, setting, and participants

A convenience sample of students enrolled in a tertiary dance training program was invited to participate in a longitudinal descriptive epidemiology study in either their second, fourth or sixth semester of a six-semester, three-year undergraduate course, training in ballet and contemporary dance. All students enrolled in the training program were eligible to participate, and were asked to give access to their: 1. physiotherapy injury records from a weekly in-house clinic; 2. course timetables; and 3. course enrolment information for retrospective analysis of the previous one, three or five semesters of their training, starting from the commencement of their program. Participation in the prospective study involved semester-long monitoring of injury (i.e., presentation to the

in-house injury clinic), as per previous semesters, as well as completion of questionnaires to monitor their load via reporting their session rating of perceived exertion (sRPE), mood and stress. The prospective semester-long monitoring occurred at the same time, conducted in either the second, fourth or sixth semesters of training. Written informed consent was obtained for participation in this study. The University Human Research Ethics Committee approved this study (approval number 1700000397). The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines (Von Elm et al., 2007) were followed for this investigation.

Variables and data sources

Injury surveillance

Data were extracted, de-identified, coded, and categorised from records (both retrospectively and prospectively) similarly to previous reports (Fuller, Moyle & Minett, 2020) by a postgraduate qualified physiotherapist with ten years of clinical dance experience. Extracted data included: week of reported onset of injury across the program; whether time-loss (TL) or activity modification was required/recommended; nature of injury (traumatic vs overuse); and whether students were required to defer their studies due to injury. Injury data were given an Orchard Sports Injury Classification System (OSICS) version 10.1 (Orchard et al., 2010) code, and given a clinical categorisation for subsequent injuries, after an initial index injury, using the Subsequent Injury Categorisation 2.0 model (Toohey et al., 2018). The reported activity (i.e., technique class, rehearsal) at the onset of the injury was also extracted. A medical attention injury definition was utilised, including injuries presenting to the in-house injury clinic, related to dance training (Kenny, Whittaker, and Emery, 2018).

Prospective monitoring

The Brunel Mood Scale (BRUMs) (Terry, Lane, and Fogarty, 2003) and the Perceived Stress Scale-10 (PSS) (Cohen and Williamson, 1988; Cohen, Kamarck, and Mermelstein, 1983) were used to monitor mood and stress respectively. Participants were asked to complete hardcopy questionnaires in the first, fourth, eighth, tenth, twelfth, and fourteenth weeks of the 14-week semester. These time points were chosen in line with the questionnaires' focus on the 'last month', with the time points narrowed at the end of the semester to more closely identify changes around assessment (Week 11), rehearsals leading to performances (Week 12 and 13), and performances (Week 14). Final-year students involved in an international dance tour completed the questionnaires two weeks before commencement of the semester and when returning from the tour in Week 3. If participants reported elevated mood and stress questionnaire scores, they were advised of available psychological support services. Participants were also asked to record daily sRPE, collected weekly across the semester, and report when they completed their daily sRPE. This data was collected by pen and paper and the scale used was the 10-point scale as per Foster et al. (2001). Participants were instructed to complete their ratings within 30 minutes of the day's training and were asked: "What is your perceived level of exertion for your physical training today?". No reminders were sent to participants to complete the measures to consider the feasibility of monitoring implementation with minimal resources.

Statistical methods

Participants' age, height and weight were described using mean, standard deviation (SD) and range data measured during the first week of the study, except for age calculated to be after data collection. The number of injuries per participant was used to show injuries in each program week, to account for varying numbers of participants for

the three-year levels. Rate ratios (RaR) were calculated for each week within each semester relative to all other weeks of the semester. Exact 95%CI were used, considered to be more ideal for a small sample size (Knowles, Marshall, and Guskiewicz, 2006; Martin and Austin, 1996), and Mid-P Exact 95%CI were calculated using online software OpenEpi (https://www.openepi.com/PersonTime2/PersonTime2.htm) (Dean, Sullivan, and Soe, 2013). Injuries with a reported onset in weeks found to have statistically significant RaR for the group were further described individually, focusing on their relationship to previous injuries within the participant. These individual injuries at times of greater group susceptibility were described for anatomical location, and tissue injured using the first two letters of the OSICS code (Orchard et al., 2010), and described for clinical category (related/unrelated) for subsequent injuries categorised for site, nature, side, structure, and recovery (Toohey et al., 2018). Other injuries outside identified times of increased group susceptibility to injury will not be discussed in such detail for brevity.

Compliance was demonstrated as the number of participants to complete the questionnaires, in relation to the number of participants for each week of the semester for the prospective analysis. Weekly load was calculated by multiplying the reported sRPE by the number of dance training minutes (Foster et al., 2001) determined from timetables and enrolment, reported in arbitrary units (AU), as the mean and SD. Absence from daily training was detected by the participants' report of a zero sRPE. The mean and SD were reported for mood and stress subscales of the BRUMs. Patterns will be visually observed from line graphs to determine increases, decreases, and spikes. Compliance, weekly load, each BRUMs mood subscale (i.e., anger, confusion, depression, fatigue, tension, vigour), stress, and the number of injuries were presented separately for students who commenced the semester in Week 1, and for those who participated in an international tour before the semester started. Data beyond RaR calculations were analysed using MS Excel v1706

(Microsoft Corporation, Redmond, USA). Statistical significance was determined via 95%CI that did not contain the null value of 1.0, thus inferring a P-value $\geq$ 0.05 (Poole, 2001). Further statistical analysis was not performed due to the small sample size, with participation rate reported on recruitment of a convenience sample, thus a power analysis was not required.

Results

Participant and injury characteristics

Fourteen dance students consented to participate (41% of the cohort; mean age at finish of data collection period= 19.3 ± 1.38; range= 17-21; 14 female, six first-years, two second-years, six third-years; mean height= 168.3cm ± 6.86; mean weight= 61.1kg ± 8.45). One semester was prospectively analysed—the second, fourth or sixth semester, depending on year level. Previous semesters were retrospectively analysed—one previous semester for first-year students (n=6), three previous semesters for second-year students (n=2), and five previous semesters for third-year students (n=6). Sixty injuries were sustained in total, with 46 among the third-year participants; six of the total injuries required TL, and the TL was for 24 hours or more for four students (three third-years and one second-year). Thirty-seven injuries (62%) required training modification without withdrawing from participation, and eight injuries (13%) were traumatic. One student deferred their studies due to injury between their first and second year. Three first-year students did not sustain any injury. All other students sustained at least one injury (n=11), with 63% of injuries sustained by three third-year participants.

Training characteristics

The training program has been described elsewhere (Fuller, Moyle & Minett, 2020) for a separate cohort. Each semester involved academic assessments in Week 11,

performance rehearsals in Weeks 12 and 13, and a performance season in Week 14. A one-week mid-semester break was scheduled between Weeks 4 to 8 during the first semester of each academic year and Weeks 9 to 11 in the second semester. In the final semester of the program, third-year students were given the option to participate in an international study tour, which extended the semester by two weeks, including training and performances for some students (n=5). Injuries per participant are shown in Figure 1 for each week of each semester of the training program.

Weeks within semesters with a significantly increased injury rate

Weeks with significantly higher RaR of injury relative to other weeks within the semester were identified. The injury RaR for Week 5 of Semester 1 was 5.78 (95%CI: 1.55, 18.48). This was the first week of technique classes (26.5 hours, inclusive of 1.5 hours conditioning) after a conditioning schedule to commence the program, involving a range of three to 14.25 hours per week, and from two conditioning sessions alone, to three conditioning sessions, with seven technique classes in the week. Two of the four injuries sustained in this week were reported to occur during contemporary dance technique classes. Week 2 of Semester 2 of training RaR was 7.62 (95%CI: 1.96, 26.30), with all four injuries reported to occur during rehearsal. Week 1 of Semester 3 RaR was 4.88 (95%CI: 1.05, 17.81). Week 1 of Semester 4 had a RaR of 13 (95%CI: 1.35, 124.90); no significant differences for RaR were identified for Semester 5 and 6, with nine injuries sustained by four participants, and 12 injuries sustained by four participants in Semesters 5 and 6 respectively.

Injuries within weeks with increased injury rate and within participant injury history

See Table 1 for a description of the injuries with a reported onset within weeks with significantly increased injury rates and participant injury history. Three participants

sustained the four injuries in Week 5 of Semester 1. Eight further injuries were reported in Semester 1, in four further participants, resulting in 13 injuries sustained in seven participants in Semester 1. Four injuries were sustained in Week 2 of Semester 2, in three participants. A further six injuries were sustained in Semester 2, totalling eleven Semester 2 injuries in eight participants. Three overuse injuries were sustained by three participants in Week 1 of Semester 3. The three injuries in Week 1 of Semester 3 are all considered clinically related injuries to previous within-participant injuries in Semester 2, impacting the same site, tissue, side, and anatomical structure after recovery. Two of these prior clinically related injuries occurred in the latter weeks of Semester 2. There were seven other injuries sustained by five participants in Semester 3. Thus, 11 injuries were sustained by six participants in Semester 3. One participant sustained two injuries in Week 1 of Semester 4, with a significantly increased rate of injuries relative to other weeks of this semester. One additional participant sustained two other injuries in Semester 4.

Prospective monitoring for injury, load, mood, and stress

Groups were separated into participants who did not participate in an international dance tour (Figure 2), and students who did and therefore commenced the semester two weeks earlier (Figure 3). Compliance decreased from 81% for the cohort not on tour to 0% for the cohort that went on tour to collect weekly session load, and mood and stress questionnaires across the semester. For the cohort not on the international dance tour (Figure 2), there appeared to be a trend of increasing anger and decreasing vigour across the semester. An apparent spike in stress was seen for this group in Week 12, a rehearsal week. For the cohort that completed the international dance tour (Figure 3), there appeared to be a trend of increasing fatigue and decreasing confusion across the semester.

A spike in stress scores was observed in the rehearsal week preceding the international dance tour, and an increase in fatigue was seen pre-to-post the international dance tour.

Discussion

This study aimed to analyse injuries and monitor load, mood and stress within semesters of a three-year tertiary dance training program. This investigation is one of few studies to report on weekly injury patterns in dance (Boeding et al., 2019; Kenny et al., 2018; Liederbach, Glein, and Nicholas, 1994), and the second study to consider clinical relatedness (Toohey et al., 2018; Toohey et al., 2019) of subsequent injuries. The preliminary findings show when injuries occurred within each semester of training of the three-year program, within participant injury patterns, patterns of load, mood, and stress within one semester of training, and compliance to complete monitoring questionnaires. We found that injury rates were significantly increased for Weeks 5, 2, and 1 of Semesters 1, 2, 3, and 4, respectively. A pattern of increasing fatigue in participants involved in an international dance tour across one semester (Semester 6) was observed. Compliance was poor regarding completing load, mood, and stress monitoring questionnaires. Our investigation gives insight into stress experienced leading up to performance periods, clinical relatedness of subsequent injuries, and injury spikes when returning to regular dance training in a tertiary dance cohort.

Weeks within semesters with a significantly increased rate of injury and within-participant injury history for significant weeks

The increased rate of injuries observed in Week 5 of Semester 1 (RaR=5.78, 95%CI: 1.55, 18.48) may be related to the commencement of technique classes, as the previous four weeks were comprised of a different conditioning timetable. Even at this early stage of training, two injuries sustained in this week were incurred after a prior injury, and considered to be clinically related (See Table 1.). This increased rate of

injuries in Week 5 could also be associated with a lag between commencing unaccustomed conditioning training in Week 1, which has also been demonstrated in a cricket population (Orchard et al., 2009). An increase in injuries after a conditioning period has been shown by Baker et al. (2010) in first-year contemporary dance students. This may reveal that the implementation of lengthy conditioning programs at the commencement of full-time dance training could be misguided, potentially being insufficient to prepare dance students for full-time technique training, or perhaps relate to unaccustomed modes of conditioning. The increased injury rate in Week 5 of Semester 1 reflects increased training demands around this time.

Two of four injuries in Week 5 of Semester 1 were reported during contemporary dance technique classes, and three were upper limb injuries. Differences have been observed regarding contemporary technique compared to ballet technique (Jeffries, Wallace, and Coutts, 2017; Liederbach et al., 2006), and the findings may indicate that this cohort was better accustomed to the latter. Another study showed upper limb injuries to be higher among contemporary dance students than ballet students and for first-year students relative to later year levels (Lee et al., 2017), supporting this investigation's findings.

Weeks 1 or 2 of Semesters 2, 3 and 4 of the program had significantly higher injury rates. Injuries this close to the end of a holiday period could be related to potential physical deconditioning. The findings of Kenny et al. (2018) support a spike in injuries associated with holiday periods, and a systematic review with meta-analysis (Fuller, Moyle, Hunt, and Minett, 2020) discussed this trend among students returning to dance at the start of the year. All injuries reported in Week 1 of Semester 3 were considered clinically related to previous injuries in the previous semester. These injuries were considered to have reoccurred after recovery, in contrast to Toohey et al. (2019) where

no subsequent injuries were clinically categorised in this way. This may demonstrate that a holiday period is not enough to address injury recurrence if appropriate rehabilitation is not conducted, with the onsite clinic directed at initial assessment and not ongoing injury management.

Week 9 in Semester 6 showed the highest number of injuries per participant across the program; however, only for one participant of six in this year level (Figure 1). Fatigue (Figure 3g) tended to increase across this semester for participants who participated in an international tour. Fatigue is related to injury in professional ballet dancers; Liederbach, Gleim, and Nicholas (1994) showed a spike in fatigue in the fourth week of a five-week performance season coinciding with an increase in injury, as well as a decrease in vigour.

Prospective monitoring for injury, load, mood, and stress

A spike in weekly load (Figure 3c) was seen at the semester's commencement for those travelling internationally. An increase in injuries (Figure 1 and 3a) was seen in Weeks 3 and 4 (Week 5 and Week 6 post-holidays) as the students returned from the tour and recommenced their usual training schedule. This could be interpreted as reflecting an increase in training when returning to a normal schedule of technique classes, rehearsal hours, and possibly working with new choreographers. A spike in training load can also be observed for Week 2 of the semester for those who did not travel internationally, which is in parallel to a spike in injuries (Figure 2a, c). This could relate to a return to dance at the start of the semester, as discussed previously. Weekly loads fluctuated across the semester with no apparent pattern, except for the decreases with no scheduled training in the mid-semester break.

A decrease in vigour (Figure 2i) was observed across the semester for students who did not participate in an international dance tour, and there was an increase in fatigue (Figure 3g) in those who did. These findings could be related to a lack of recovery

strategies utilised by participants. Mean confusion (Figure 3e) scores were seen to decrease across the semester in participants who went on the international dance tour. The tour's new experiences, involving travel, training, and performing overseas, may have led to higher scores at the semester's commencement. For both groups, a spike in stress (Figures 2j and 3j) coincided with rehearsal weeks leading to the international tour or performances.

Strengths and limitations

This study's strength is the small sample size, enabling a within-participant description of injury history, utilizing clinical insights at times of increased group susceptibility to injury. A limited number of students consented to participate in this research, and there was poor compliance with completing questionnaires, which may have skewed the results. Therefore, confidence in interpreting the results related to questionnaire data is limited, and there is a risk of over and under interpretation of the outcomes. The low participation and compliance with completing questionnaires may have been related to reminders not being provided, no feedback being given on the responses, and the burden of filling out questionnaires over an extended time frame. Although participants were requested to complete sRPE entries daily, they were on occasion completed retrospectively, as reported by the participants. These data were only included if the entry was made within the same week of data collection. Only dance-related injuries were included; injuries that occurred outside of training may, therefore, have confounded the findings. Further, some injuries may have been presented to external practitioners and not the onsite clinic and would thus have been missed from this analysis. It is also recognised that a small number of participants sustained a relatively high proportion of injuries, and these individuals may skew the data. Reports of subjective

clinical relatedness of subsequent injuries to previous injuries should be considered cautiously.

Future directions

It is advisable to monitor the training load to understand individual responses to training (Soligard et al., 2016). Challenges to implementing such monitoring via self-reporting measures have been previously recognised (Saw et al., 2017). Education, giving feedback, and the introduction of monitoring early in careers may promote buy-in (Saw, Main, and Gastin, 2015). Further research would benefit from focusing upon end-user beliefs, to assist in guiding dancer monitoring and load management to aid uptake and compliance, which were shown to be problematic in this investigation.

As advised by Jeffries and colleagues (2020), it makes sense to apply training principles (Kasper, 2019). Jeffries et al. (2020) have suggested scheduling recovery days and periods of reduced load for professional contemporary dancers. Using the principles of progression and reversibility (Kasper, 2019) for the cohort in this investigation may guide a graduated return to dance after the holidays when dancers may have deconditioned without a formal training schedule. In the focus group by Bolling et al. (2021) on professional dancers and medical and artistic staff, the importance of long-term planning was mentioned to reduce injury. Artistic staff identified barriers to planning, such as last-minute changes due to injuries impacting casting.

The participants in the focus group study by Bolling and colleagues (2021) also recognised the learning process of reducing injuries, and that young dancers have limited experience and require further education on this. Injury susceptibility to transition to professional dance or pre-professional training has been investigated in a systematic review (Fuller et al., 2019). Education on injury prevention may be even more beneficial

in pre-professional cohorts, before reaching the professional ranks with an already existing injury profile.

In this investigation, the increased injury rates near recommencing the semester were seen for earlier semesters (2-4), but not for Semesters 5 and 6. This might suggest that dancers entering their final year of training have learned to address this susceptibility to injury. However, the reader is reminded that data was only available for a sample of the participant pool (n=6) that completed their final year of training. Figure 1. takes the number of dancers/participants for each semester into account, and there does not appear to be a decrease in injuries per dancer for each week in these later semesters, thus perhaps suggesting that the decreased number of participants have influenced the findings reaching significance, and not that dancers have learned to reduce injuries across their studies. This is supported by a previous study on a separate cohort that completed their training (Fuller, Moyle & Minett, 2020), showing an increase in the incidence of injury across tertiary dance training, highlighting the need for appropriate rehabilitation of injuries that may influence the occurrence of subsequent injuries.

Implications and applications

The practical implications of the current study suggest that healthcare practitioners should work closely with dancers and dance educators to facilitate buy-in to complete monitoring. One strategy could be to initiate these practices at an earlier stage of training (Saw, Main, and Gastin, 2015). This process will aid dance educators to understand how dancers are adapting to their training and to apply training principles in response to monitoring. Specifically, dance educators should apply the progression and reversibility training principles to implement a planned, graduated return to recommence training after a holiday. In addition, healthcare practitioners and dance educators should work closely with administrators to plan schedules to ensure adequate

rest at appropriate times.

Conclusions

Overall, this study shows when injuries occurred within semesters of training of the three-year program, within participant injury patterns, patterns of load, mood, and stress within one semester of training, and compliance to complete monitoring questionnaires. Significant increases in the reported onset of injury are seen in the first or second weeks of Semesters 2 to 4, which may relate to returning to dance at the start of a semester. Spikes in load coincided with spikes in injury early in one semester. The reported onset of three injuries in the ninth week for a student in their final semester of training was the highest number of injuries per participant per dancer, and fatigue is shown to increase across the semester for this group. The authors suggest that healthcare practitioners, dancers and dance educators should work closely to facilitate compliance with monitoring practices to inform dance educators of how dancers are adapting to training. Training principles should be applied to return to dance after a holiday to reduce injuries, shown to be significant at these times. Future research should be directed towards end-user perceptions of training monitoring and the effectiveness of load management to guide the implementation of dance load management injury reduction strategies.

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Table 1. Injuries within weeks with increased injury rate and within participant injury history

Week and Semester number of injury with significantly increased rate of injury relative to other weeks within semester	Participant number	Participant injury number, type, side, location and tissue within week of interest (Orchard et al., 2010)	Subsequent injury yes/no	List prior injuries	Subsequent injury category description (Toohey et al., 2018)	Clinically related yes/no
Week 5, Semester 1	1	1. Traumatic right shoulder joint injury	No	NA	NA	NA
	2	1. Overuse left wrist joint injury	No	Injury 1. reported above.	Injury at same site, same tissue, on different side	Yes, for Injury 1 to Injury 2.
		2. Overuse right wrist joint injury	Yes			
	3	2. Overuse right knee impingement/bursitis/synovitis injury	Yes	Injury 1. Overuse right ankle tendon injury (Week 1, Semester 1)	Injury at different site, and different tissue	Yes, for Injury 1 to Injury 2.
Week 2, Semester 2	4	1. Traumatic right thigh muscle injury	No	NA	NA	NA
	2	3 and 4. Overuse bilateral shoulder impingement/bursitis/synovitis injury	Yes	Injury 1 and 2 reported above.	Injury at different site, and different tissue	No

	3	4. Overuse left foot tendon injury	Yes	Injury 1 and 2 reported above. Injury 3. Overuse right foot muscle injury (Week 1, Semester 2)	Injuries 1-3 at same or different site, and same or different tissue to Injury 4.	No
Week 1, Semester 3	3	5. Overuse left foot tendon injury	Yes	Injury 1, 2, 3, and 4 reported above.	Injuries 1-3 at same or different site, and same or different tissue to Injury 5. Injury 5 is to the same site, tissue, side, and structure after recovery of Injury 4	Yes, for Injury 4 to Injury 5.
	5	6. Overuse left lumbar degenerative disc injury	Yes	Injury 1 and 2. Overuse bilateral ankle tendon injury (Week 4, Semester 1) Injury 3. Overuse left chest joint injury (Week 13, Semester 1) Injury 5. Overuse left lumbar degenerative disc injury (Week 11, Semester 2)	Injuries 1-4 at different site, and different tissue to injury 6. Injury 6 is to the same site, tissue, side, and structure after recovery of Injury 5.	Yes, for Injury 5 to Injury 6.

	6	2. Overuse left knee haematoma injury	Yes	Injury 1. Traumatic left knee haematoma injury (Week 12, Semester 2)	Injury 2 is to the same site, tissue, side, and structure after recovery of Injury 1	Yes, for Injury 1 to Injury 2.
Week 1, Semester 4	6	6. Overuse left foot impingement/bursitis/synovitis injury 7. Overuse left knee impingement/bursitis/synovitis	Yes	Injury 1 and 2 reported above. Injury 3. Overuse left knee impingement/bursitis/synovitis injury (Week 5, Semester 3) Injury 4. Overuse right hip muscle injury (Week 6, Semester 3) Injury 5. Overuse left knee impingement/bursitis/synovitis injury	Injuries 1-5 at same or different site, and same or different tissue as Injury 6. Injuries 1-2 at same side, different tissue as Injury 7. Injury 7 at same site, tissue, side and structure after recovery of Injuries 3 and 5. Injuries 4 and 6 at different site, same or different tissue as Injury 7.	Yes, for Injury 3 and 5 to Injury 7.

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