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Original Research

Injury, Illness, and Training Load in a Professional Contemporary Dance Company: A Prospective Study

Annie C. Jeffries, BSES (Hons1), MCEP*; Lee Wallace, PhD*; Aaron J. Coutts, PhD*; Ashlea Mary Cohen, MPhys†; Alan McCall, PhD*‡; Franco M. Impellizzeri, PhD*

*Human Performance Research Centre, Faculty of Health, University of Technology Sydney, Australia; †Sydney Dance Company, Australia; ‡Arsenal Performance and Research Team, Arsenal Football Club, London, United Kingdom

Context: Professional dance is a demanding physical activity with high injury rates. Currently, no epidemiologic data exist regarding the incidence of injury and illness together with training load (TL) over a long period of time.

Objective: To provide a detailed description of injury, illness, and TL occurring in professional contemporary dancers.

Design: Descriptive epidemiology study.

Setting: A single professional contemporary dance company during a 1-year period.

Patients or Other Participants: A total of 16 male and female professional contemporary dancers.

Main Outcome Measure(s): Injury data consisted of medical-attention injury (Med-Inj) and time-loss injury (Time-Inj). Illness was measured using the Wisconsin Upper Respiratory Tract Infection Survey. Training load was collected for each dance session using the session rating of perceived exertion and classified into 3 groups based on individual and group percentiles: low, medium, or high.

Results: Reported injuries totaled 79 (86.1% new, 6.3% reinjury, and 7.6% exacerbation). The Med-Inj incidence rate was 4.6 per 1000 hours (95% confidence interval [CI] = 3.8, 5.8), and the Time-Inj rate was 1.4 per 1000 hours (95% CI = 0.8, 2.1). The median time until injury for Med-Inj and Time-Inj was 3 months. The number of days dancers experienced illness symptoms was 39.9 ± 26.9 (range = 1–96), with an incidence rate of 9.1 per 1000 hours (95% CI = 7.7, 10.7). Mean weekly TL was 6685 ± 1605 (4641–10 391; arbitrary units). Inconsistent results were found for the incidence of injury and illness based on individual and group categorizations of TL.

Conclusions: Professional dancing is associated with high injury and illness rates. This is worrying from a health perspective and underlines the need for further studies to understand how to decrease the risk. The TL is higher than in other sport disciplines, but whether the high incidence of injuries and illnesses is related to high training demands needs additional investigation, possibly conducted as international, multicenter collaborative studies.

Key Words: upper respiratory tract infection, rating of perceived exertion, individual differences, injury surveillance

Key Points

- Professional dancers experienced high training loads relative to other sports and concomitantly high injury and illness incidence and risk.
- Dancers continued with training, albeit modified, even when affected by medical-attention injuries and illnesses.
- The median survival time without injury for both medical-attention and time-loss injury was 3 months.
- Inconsistent results were present for the incidence of injury and illness based on individual and group categorizations of training load.
- Future interventions may include modifying the training distribution, including recovery days, and reducing load for short periods.

The injury incidence rates reported in professional dancers range from 0.16 to 4.44 per 1000 hours of exposure.[1–3] This large variation may be due to a number of factors, including injury definition, style of dance (ie, contemporary or ballet), repertoire, and tour schedule. However, research on injury incidence and risk factors in dance is both limited and methodologically inconsistent compared with investigations of many other athletic activities.

Previous researchers[4] demonstrated that the cumulative effects of repeated, intense physiological and psychological training can disrupt immune system function. In particular, the risk of upper respiratory tract infection (URTI) has also been shown to increase during periods of intensive training in elite athletes competing in a variety of sporting contexts (eg, swimming, tennis, and team sports).[4–6] Furthermore, URTI is usually preceded by a prodromal period involving pathophysiological changes of fatigue, myalgia, and headache. These early warning symptoms may be indicators of acute illness as well as symptoms of overreaching and overtraining.[7] Accordingly, monitoring athletes is essential in understanding the relationship between physical training and immunologic changes. However, despite high psychophysiological demands, no researchers have inves-

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Table 1. Participants' Baseline Characteristics, Surveillance Period 2018–2019

Characteristic	Men (n = 7)	Women (n = 9)	Total (n = 16)
Previous injury, n (%)[a]	6 (85.7)	9 (100)	15 (93.7)
		Mean ± SD (Range)	
Age, y	27.6 ± 5.5 (19–34)	24.9 ± 4.7 (18–32)	26.1 ± 5.1 (18–34)
Height, cm	177.1 ± 7.9 (170.9–191.2)	161.7 ± 3.5 (156.4–165.5)	168.4 ± 9.6 (156.4–191.2)
Weight, kg	72.1 ± 6.9 (64.4–81.6)	51.8 ± 4.0 (47.2–60.2)	60.7 ± 11.6 (47.2–81.6)
Professional dance experience, y	14.1 ± 4.8 (6–20)	21.2 ± 3.3 (17–26)	18.1 ± 5.3 (6–26.0)

[a] Previous injury includes new injury, reinjury, and exacerbations.

tigated the incidence of URTI or the effect of illness on dancers.

Inappropriate balance between training load (TL) and recovery has also been suggested to induce fatigue, abnormal training responses,[7] and increased risk of injury and illness.[8] Despite substantial research on TL and injury, results are inconsistent and appear to vary with the type and time frame of load measured.[9] Only 1 group[10] has examined injury (overuse) and TL in dance: they found that dancers without musculoskeletal pain had lower TLs. For example, the TL of dancers with self-reported symptoms of overuse injury was higher than that of dancers with no symptoms. However, caution is warranted when interpreting these findings due to methodologic concerns, including a short observation period (7 weeks) and missed data (time-loss or medical-attention injuries). Furthermore, although data from single small cohorts cannot be generalized, the combination of results from multiple cohorts may provide more insight and external validity. Therefore, investigations that are longitudinal in nature, have a longer risk period, and provide comprehensive data on injury incidence and TL are needed. These may assist our appraisal of the mechanisms of injury and prompt suggestions of preventive interventions for future studies.

To date, no authors have examined injury, illness, and TL in the same dance cohort using a prospective approach. Given the potential risks to the health of dancers (eg, injury and illness) and their multifactorial nature, it is important to obtain more data regarding the characteristics of injury, incidence of illness, and TL volume across a season. This will provide useful information for identifying potential factors for prognostic research. Thus, the purpose of our study was to provide detailed descriptions of injuries, illnesses, and TL in professional contemporary dancers.

METHODS

Population

Active professional contemporary dancers from the same dance company were eligible to participate in the study on a voluntary basis. Sixteen dancers, 7 men and 9 women (see baseline characteristics in Table 1), agreed to participate in this study. Ethical approval was granted by the University of Technology Sydney Human Research Ethics Committee (HREC ETH17-1082) before the study began. Each participant provided written informed consent and was familiarized with all procedures before the start of the study.

Study Design

We used a prospective cohort research design in which injury, illness, and TL data were collected during a 1-year period (2018–2019) in Sydney, Australia. The study location was the dance company's training base or domestic and international performing venues. All injuries sustained during the surveillance period were recorded by the company physiotherapist, and no participants' data were excluded from the analysis. Injury reporting and methods were based on guidelines from the International Association of Dance Medicine and Science[11] and international consensus statements.[12,13] The reporting of this study follows the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.[13]

Injury Definition, Classification, and Severity and Injury Rate

Injuries were defined as a (1) *medical-attention injury* (Med-Inj): assessment of a participant's medical condition by a qualified physiotherapist[12] or (2) *time-loss injury* (Time-Inj): a participant was unable to dance for 1 or more days after the event.[14] Information was collected regarding injury status (new, no previous history; reinjury, repeat episode of a fully recovered injury; exacerbation, worsening of a nonrecovered injury),[12] mechanism of injury, location, injury occurrence, type of onset,[12] report of cause, contact or noncontact, detailed injury assessment, and exposure status.

Injuries were classified into 3 categories of severity according to the length of absence from full training, with the day on which the injury occurred being counted as day zero: *minor* (1–7 days), *moderate* (8–28 days), and *severe* (>28 days). *Dance exposure* was defined as the time during which individuals were at risk of injury (hours spent participating in dance class, rehearsal, or performance). Injury incidence rate was calculated as all new Med-Injs per 1000 h and all new Time-Injs per 1000 hours. The Med-Inj and Time-Inj incidence rates were calculated for each training mode. Additionally, the Med-Inj and Time-Inj incidence rates were calculated for group and individual daily and weekly TL percentiles (low, medium, and high).

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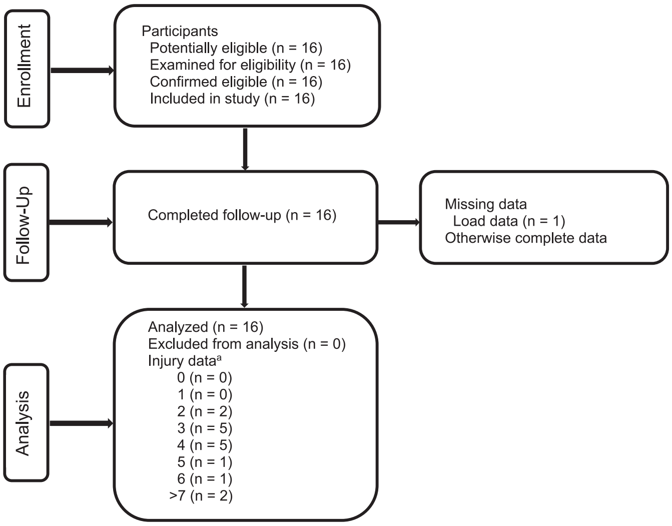

Figure 1. Flow diagram of study design. [a] Injury: medical attention injury (Med-Inj).

Illness

The Wisconsin Upper Respiratory Tract Infection Survey contains 10 items that assess symptoms, 9 items that assess functional impairments, and 1 item that assesses global severity and global change. For a URTI to be recorded, participants must have had upper respiratory signs and symptoms for $\geq$48 hours. For calculation of the illness incidence rate, participants were considered at risk of a new illness during dance training exposure minus both the duration of each illness episode and the 7 days after each episode. Illness incidence rates were also calculated based on group and individual daily and weekly TL percentiles (low, medium, and high).

Training Load

Sessions were classified by the following training modes: ballet and contemporary class, rehearsals, and performance. The internal TL for each session was calculated using the session rating of perceived exertion (sRPE) method for each dancer during the study period.[15] The sRPE was calculated as the product of exercise intensity and exercise duration. Exercise intensity was determined by the sRPE according to the Borg CR-10 scale[16] and was collected within 10 minutes after each class. The sRPE method has been validated[17] as a measure of internal TL in preprofessional dancers. In addition, the sum of the daily and weekly TLs was calculated for individual and group percentiles (low, medium, and high) and each type of session (ballet, contemporary, rehearsal, and performance).

Data Collection

All injury, illness, and TL data were prospectively collected and recorded in a centralized database (Edge10, London, UK) using a custom-designed app. Each injury was assigned a 4-character injury diagnosis code (Orchard Sports Injury Classification System 10.1).[18] Injuries were time recorded according to the date of injury, and all data were linked by a unique identification code.[19] This study was part of a larger 2-year project involving data from the surveillance system.

Analyses

Descriptive analyses were performed on injuries and illnesses sustained during the 2018 surveillance period. We calculated injury and illness incidence rates using the following formula: number of new injuries per exposure in hours (individual hours collected from duration time calculated in sRPE) $\times$ 1000 and 95% confidence intervals (CIs). Kaplan-Meier injury survival analysis was conducted to determine the proportion of injury-free participants at monthly intervals for both Med-Injs and Time-Injs. All analyses were performed in Excel (version 2016; Microsoft Corp, Redmond, WA).

RESULTS

A STROBE flowchart of participants illustrates the sequential recruitment (Figure 1).

Participation and Injury Occurrence

Sixteen professional contemporary dancers (7 men, 9 women) were followed during a 1-year period that involved 14 689 participation hours. A total of 79 injuries were reported during the 1-year period (new = 86.1% [n = 68]; reinjury = 6.3% [n = 5]; exacerbation = 7.6% [n = 6]) by the 16 particpants (100%), with a Med-Inj incidence rate of 4.6 per 1000 hours (95% CI = 3.8, 5.8) and a Time-Inj incidence rate of 1.4 per 1000 hours (95% CI = 0.8, 2.1). A detailed summary of the injury distribution characteristics and incidence rates is presented in Table 2. Most of the reported injuries (70.6%, n = 59) resulted in no time loss from dance training or performance. The Med-Inj incidence rate for each session was as follows: ballet = 4.4 per 1000 hours (95% CI = 1.9, 9.1), contemporary = 4.7 per 1000 hours (95% CI = 2.3, 9.2), rehearsal = 4.9 per 1000 hours (95% CI = 3.6, 6.5), and performance = 3.1 per 1000 hours (95% CI = 1.1, 8.1). The greater risk difference was between performance and contemporary sessions: 2.1 (95% CI = –2.6, 6.7; P = .58). The Time-Inj incidence rate for each session was ballet = 0.0 per 1000 hours, contemporary = 1.2 per 1000 hours (95% CI = 0.3, 4.6), rehearsal = 1.4 per 1000 hours (95% CI = 0.8, 2.2), and performance = 2.1 per 1000 hours (95% CI = 0.7, 6.5).

Types of Injuries Sustained

The majority of Med-Injs were to the knee (16.5%, n = 13), upper leg (15.2%, n = 12), and torso (15.2%, n = 12), which resulted in median time losses of 13 days (range = 4–90), 3.5 days (range = 1–10), and 6.5 days (range = 2–14), respectively. The most common type of injury (69.6%, n = 55) was ligament-joint and muscle-tendon (26.6%, n = 21), with median time losses of 4 days and 6 days (Table 3), respectively. Acute injuries were the most frequent type of injury, accounting for 74.7% (n = 59), with gradual injuries responsible for only 25.3% (n = 20).

The majority of Time-Injs were to the ankle (25%, n = 5), upper leg (20%, n = 4), and torso (20%, n = 4), which resulted in median time losses of 21 days (range = 5–28), 5 days (range = 1–10), and 5 days (range = 2–14), respectively. Ligaments and joints were injured most often (65%, n = 13). Acute injuries were the most common type, accounting for 90% (n = 18), with gradual injuries accounting for only 10% (n = 2).

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Table 2. Injury Distribution Characteristics, Participants Injured, and Incidence Rates Across 1 Year (N = 16)

Measure	2018–2019		
	Men (n = 7)	Women (n = 9)	Total (n = 16)
Total participants, No.			
Injured	7	9	16
Noninjured	0	0	0
Total injuries sustained, No.			
Non–time loss	24	44	68
Time loss	11	9	20
Injuries			
Median (range)	3 (2–8)	4 (3–11)	4 (2–11)
Incidence rate (×1000 hours)[a]			
Medical attention (95% CI)	3.4 (2.2, 5.0)	5.1 (3.8, 6.8)	4.6 (3.8, 5.8)
Time loss (95% CI)	1.6 (0.86, 2.8)	1.0 (0.5, 2.0)	1.4 (0.8, 2.1)
Injuries, No. (%)			
0	0 (0.0)	0 (0.0)	0 (0.0)
1	0 (0.0)	0 (0.0)	0 (0.0)
2	2 (28.6)	0 (0.0)	2 (12.5)
3	2 (28.6)	3 (33.3)	5 (31.3)
4	2 (28.6)	3 (33.3)	5 (31.3)
5	0 (0.0)	1 (11.1)	1 (6.3)
6	1 (14.3)	0 (0.0)	1 (6.3)
7+	0 (0.0)	2 (22.2)	2 (12.5)
Time-loss injuries, No. (%)			
0	1 (14.3)	5 (55.6)	6 (37.5)
1	2 (28.6)	2 (22.2)	4 (25.0)
2	3 (42.9)	0 (0.0)	3 (18.8)
3	1 (14.3)	1 (11.1)	2 (12.5)
4	0 (0.0)	1 (11.1)	1 (6.3)

Abbreviation: CI, confidence interval.

[a] Number of new injuries per 1000 exposure hours.

Injury Severity

Time-loss injuries constituted 29.4% (n = 20) of all injuries, resulting in 261 days away from dance. Sixty percent (n = 12) of all Time-Injs required the participant to take ≤7 days off dance; 35% took 8 to 28 days off and 5% took >28 days off (Figure 2). Injuries that necessitated the greatest time away from dance were meniscal injuries, ankle sprains, and muscle strains.

Time to Injury

The starting point for the survival analysis was the beginning of the study. Participants were followed until the first new Med-Inj and Time-Inj occurred. We calculated Kaplan-Meier curves to estimate the survival function for the time to the first injury in all injured participants (Figure 3). All participants were injury free at the onset of the study.

Illness

A total of 134 illness episodes were reported across the 1-year surveillance period, with no missing data. The illness incidence rate was 9.1 per 1000 hours (95% CI = 7.7, 10.7). The number of days participants experienced URTI symptoms was 39.9 ± 26.9 (mean ± standard deviation [SD]; range = 1–96).

Training Load

The average weekly TL was 6685 ± 1605 (range = 4641–10 391) arbitrary units (AU). The average TLs for individual sessions were ballet = 407 ± 120 (range = 70–1200) AU, contemporary = 387 ± 153 (range = 30–1620) AU, rehearsal = 578 ± 303 (range = 20–1800) AU, and performance = 691 ± 350 (range = 40–1800) AU. The group average RPE was highest in performance (8.0 ± 1.4) and lowest for contemporary (5.0 ± 1.4) as shown in Appendix A.

For the analysis of the effect of TL on injury, complete data were collected for injury and less than 10% of data were missing for TL. The missing data for TL were all from 1 participant (participant No. S3, injuries = 4). The main analysis used single imputation (mean TL imputed for missing TL data), and the results are provided in Table 4. Sensitivity analysis was conducted as follows: (1) non-imputed data (n = 16); (2) imputation of maximum TL observed on that day or week from the remaining participants entered as the missing value for dancer S3; (3) imputation of minimum TL observed on that day or week from the remaining participants entered as the missing value for participant No. S3; and (4) nonimputed data excluding participant No. S3 (n = 15). The results of the sensitivity analysis were similar and did not change the interpretation of the data (data not shown). This suggests

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Table 3. Body Region and Tissue Classification of New Injuries

Tissue/Body Region	Diagnosis	Frequency (%)
Bone fracture–stress reaction		1 (1.3)
Foot-toe	2nd metatarsal stress reaction–fracture	1 (100)
Muscle-tendon-bursa		21 (26.6)
Foot	Peroneal tendinopathy	1 (4.8)
	Web-space bursitis	1 (4.8)
Ankle	Achilles tendinopathy	1 (4.8)
	Flexor hallucis longus tenosynovitis	1 (4.8)
Lower leg	Achilles tendinopathy	2 (9.5)
Knee	Patellar tendinopathy	1 (4.8)
Upper leg	Hamstrings insertional tendinopathy	5 (23.8)
	Adductor and quadriceps fascial tear	1 (4.8)
	Quadriceps fascial irritation	1 (4.8)
	Rectus femoris strain	1 (4.8)
	Biceps femoris strain	1 (4.8)
	Myotendinous junction hamstrings strain	1 (4.8)
	Adductor longus strain	1 (4.8)
	Iliotibial band friction syndrome	1 (4.8)
Torso	External oblique strain	1 (4.8)
	Rectus abdominis strain	1 (4.8)
Joint-ligament		55 (69.6)
Toe	Metatarsophalangeal joint sprain	3 (5.5)
Foot	Cuboid dysfunction	3 (5.5)
	Midfoot joint sprain	2 (3.6)
Ankle	Lateral ankle sprain	5 (9.1)
	Anterior ankle impingement	1 (1.8)
Knee	Patellofemoral pain syndrome	4 (7.3)
	Meniscal tear-irritation	3 (5.5)
	Meniscal irritation	1 (1.8)
	Fat pad impingement	2 (3.6)
	Tibiofemoral joint cartilage irritation	2 (3.6)
Hip	Hip impingement	8 (14.5)
	Hip instability	1 (1.8)
Pelvis	Sacroiliac joint dysfunction	2 (3.6)
Torso	Facet joint irritation	6 (10.9)
	Rib dysfunction	3 (5.5)
Shoulder	Shoulder impingement	3 (5.5)
	Shoulder dislocation	1 (1.8)
Elbow	Ligament sprain	1 (1.8)
Wrist	Scapholunate sprain	1 (1.8)
	Triangular fibrocartilage complex sprain	2 (3.6)
Hand	Radiocarpal joint synovitis	1 (1.8)
Central or peripheral nervous system-nerve		2 (2.5)
Neck	Disc irritation	1 (50)
Torso	Neural tension	1 (50)

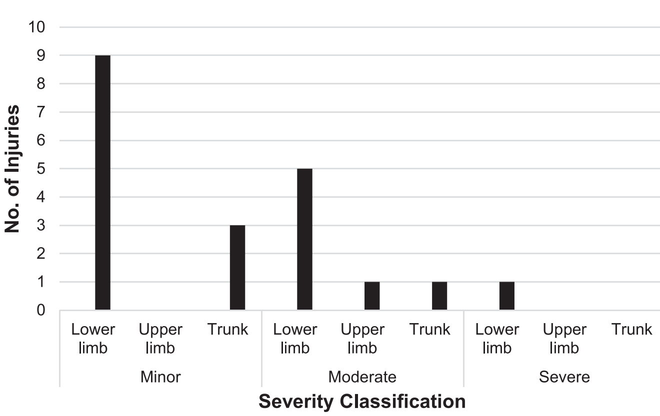

Figure 2. Distribution of injury severity by injury location.

that the distribution of missing data is consistent with the assumption that the data are missing at random.

Injury and Training Load

Based on group TL percentiles, the Med-Inj incidence in the high TL group was 5.7 per 1000 hours; medium, 3.6 per 1000 hours ($P = .08$); and low, 3.2 per 1000 hours ($P = .17$). Based on participants' individual TL percentiles, the greater daily Med-Inj incidence rate was in the low TL group (6.6 per 1000 hours, 95% CI = 4.4, 9.7), and the greater weekly injury incidence rate was in the medium group (5.9 per 1000 hours, 95% CI = 4.2, 8.3) as shown in Table 4. Additionally, we calculated the injury incidence rates for Med-Injs and Time-Injs during each type of session based on participants' individual TL percentiles.

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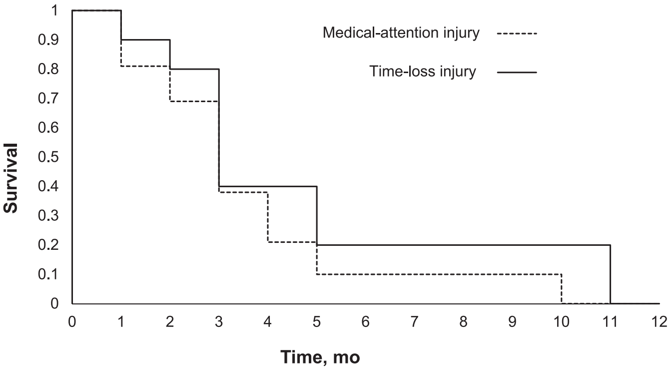

Figure 3. Kaplan-Meier curve of the time until first medical-attention injury as indicated by the dotted line (n = 16) and time-loss injury as indicated by the continuous line (n = 10) in professional contemporary dancers during 2018–2019. Survival: cumulative incidence probability. Vertical dropdown lines signify when an injury occurred.

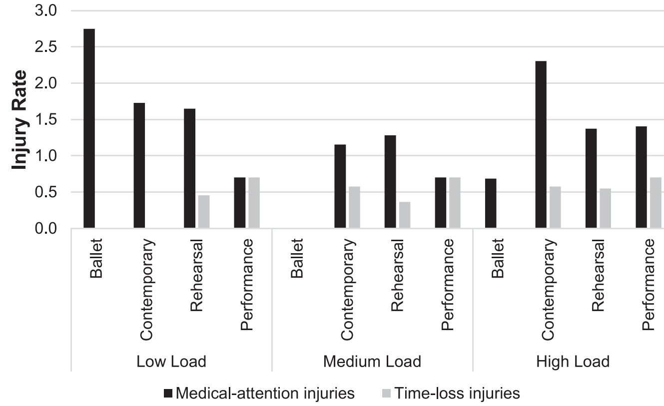

Figure 4. Injury incidence rate per 1000 exposure hours (medical-attention injury and time-loss injury) for individual training load percentiles (low, medium, and high) for each dance session: ballet, contemporary, rehearsal, and performance.

For Med-Injs, ballet in the low TL percentile group had the greater injury rate at 2.7 per 1000 hours (95% CI = 1.0, 7.31) and the smallest injury incidence rate of 0.0 per 1000 hours in the medium TL group. For Time-Injs, performance had the greater incidence rate for all 3 categories of TL at 0.7 per 1000 h (95% CI = 0.09, 4.9) as displayed in Figure 4.

Illness and Training Load

The number of days participants experienced URTI symptoms in the high TL group was 52.2 ± 26.6 (range = 19–96), in the medium TL group was 47.8 ± 19.7 (range = 18–69), and in the low TL group was 19.6 ± 21.3 (range = 1–60). The illness rates were 3.9 per 1000 hours (95% CI = 2.9, 5.0) for the high TL group, 3.4 per 1000 hours (95% CI = 2.5, 4.4) for the medium TL group, and 1.8 per 1000 hours (95% CI = 1.2, 2.6) for the low TL group.

DISCUSSION

The purpose of our study was to provide a detailed description of injury, illness, and TL in professional contemporary dancers. We are the first to comprehensively examine the combination of injury, illness, and TL in the same population over an extended, continuous surveillance period. The key findings of our investigation were (1) high injury rates, particularly Time-Injs, (2) high illness rates and lengthy durations of URTI symptoms, (3) a median time to injury of 3 months, and (4) injury and illness rates in relation to TL depended on the categorization and reference method. Although a number of previous researchers[1,2,20] explored injury rates in professional dancers, only 1 group[10] concurrently assessed injury and TL. However, that study lasted 7 weeks, and no time-loss or medical-attention injuries were reported.[10] Additionally, no authors have examined illness in dancers.

Injury Occurrence

Our entire cohort of participants (100%) acquired at least 2 Med-Injs during the surveillance period, and several participants experienced >7 new injuries. The Med-Inj incidence rate (4.6 per 1000 hours) was similar to that reported in a prospective epidemiologic study of professional ballet dancers (4.44 per 1000 hours).[3] However, the Time-Inj incidence rate was higher (1.4 per 1000 hours) than in several evaluations of similar contemporary dancers (0.16–0.22 per 1000 hours).[1,14] Several factors may have contributed to these differences, including the repertoire, demographics, and study durations. For example, one investigation[1] spanned a 15-year period, compared with our 1-year duration. In addition, our injury incidence rates for individual sessions ranged from 4.9 per 1000 hours for rehearsal to 3.1 per 1000 hours for performance. In contrast, a previous group[3] who studied professional ballet dancers reported lower injury incidence rates for rehearsal (2.43–2.99 per 1000 hours) and higher rates for performance (4.45–5.19 per 1000 hours). This difference might be due to variations in dance style and the intensity of rehearsal sessions. We reported 261 days for Time-Injs and 447 days of training (in a modifed form) for Med-Injs. Furthermore, 4 dancers missed performances due to new injuries and 1 due to reinjury during the surveillance period. This shows that dancers persisted in training and performance despite the presence of injury or a medical complaint.

Table 4. Individual Daily and Weekly Injury and Illness Rates for Training-Load Percentiles (Mean Imputation)

	Training Load, Arbitrary Units (95% Confidence Interval)					
	Low		Medium		High	
Variable	Daily	Weekly	Daily	Weekly	Daily	Weekly
Medical-attention injury	6.6 (4.4, 9.7)	4.0 (2.1, 7.4)	4.5 (3.0, 6.6)	5.9 (4.2, 8.3)	2.8 (1.8, 4.5)	3.3 (2.2, 4.8)
Time-loss injury	1.3 (0.5, 3.2)	0.8 (0.2, 3.1)	2.0 (1.1, 3.5)	1.3 (0.6, 2.6)	0.6 (0.2, 1.6)	1.4 (0.8, 2.6)
Illness rate	11.1 (8.2, 15.0)	9.6 (6.4, 14.2)	6.8 (4.9, 9.4)	9.1 (6.9, 11.9)	8.5 (6.5, 11.0)	7.8 (6.0, 10.0)

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Types of Injuries Sustained

In the current study, ligaments and joints were injured most commonly, predominantly in the lower extremities, with hip impingement accounting for the majority. In contrast, ligament and joint injuries accounted for only 35% of all injury types in a study of a similar cohort.[14] Additionally, despite overuse injuries being cited as the most frequent type of injury in dancers,[2] we found that overuse injuries were responsible for only 25.3%. This variance may be due in part to differences in definitions of overuse injuries. For example, no current consensus exists on the definition of overuse injury; some researchers[21] considered overuse a mechanism of injury, whereas others[20] used a diagnosis-based definition. Overall, we identified a wide range of injury types that should be considered when injury-prevention programs are being developed or casual associations are being examined in future etiologic studies.

Time to Injury

This is the first study, to our knowledge, to examine the time-to-event analysis of injury in professional contemporary dancers. The Kaplan-Meier analysis involves calculation of the probability of injury at the time of occurence. We determined that the median survival time without injury for both Med-Inj and Time-Inj was 3 months. Within the first 5 months of the surveillance period, all participants except 1 experienced their first Med-Inj. Furthermore, the most severe injuries (meniscal tear requiring surgical repair, grade 3 lateral ankle sprain) occurred in the first quarter of the year. Based on limited numbers, these results suggest that dance is a very high-risk discipline, underlining the need for further research to support the implementation of injury-prevention programs to protect dancers' health.

Illness

Currently no investigations of illness incidence (in particular, URTI) have been conducted in professional dancers. Upper respiratory tract illness has been reported[22] as the most common reason for noninjury-related presentations to sports medicine clinics, accounting for 35% to 65% of illnesses. A major finding of our work was the high incidence of URTI, with an illness incidence rate of 9.1 per 1000 hours and 134 illness episodes. Additionally, the average duration of URTI symptoms was 39.9 ± 26.9 days, ranging from 1 day to approximately 3 months. Potential causes for high illness rates include TL management,[4,6,7] international travel,[23] and lifestyle factors.[24] However, these measures were beyond the scope of our study; further research is required to understand if these factors influence the reduction of pathogen exposure and potential immunosuppression. It should be noted that no modifications to training or time loss were reported while the dancers experienced URTIs. As such, persistent illness can have a negative effect on health and performance, particularly when undertaking high levels of strenuous exercise.[22]

Training Load

As expected, we showed that professional contemporary dancers undertook high TLs, especially in comparison with many other high-level athletes.[25,26] For example, weekly accumulated TLs in elite soccer were 2994 AU[26] and average TLs in Australian football were 4261 AU.[25] Also, the average weekly accumulated TLs (6685 ± 1605 AU) were much higher than those reported in preprofessional contemporary dancers (4283 ± 2442 AU)[17] and adolescent ballet dancers (596 ± 153 AU).[27] Collectively, these variations may reflect the increased training duration of professional dancers compared with preprofessional dancers and football players. Although the average TLs for individual sessions (contemporary, ballet, and rehearsal) were similar to those in previous reports of preprofessionals,[17] our dancers undertook more sessions per day.

Injury and Training Load

In recent years, many authors[9,28,29] have examined the association between TL and injury in various sport disciplines. Yet most of these studies were underpowered because the number of injuries required to indicate an association with TL was much higher than typically used.[30] The number of injury events we described was similar to those in previous publications but still inadequate to reliably determine associations; hence, we did not perform any predictive or associative analyses.[28,29] Rather, we accurately described the TL to help develop a conceptual framework and a causal structure that can be used in future epidemiologic studies that may require international and multicenter initiatives to obtain appropriate sample sizes.

An interesting finding of our investigation was that participants in the high TL group experienced the highest injury incidence rate (5.7 per 1000 hours) compared with the medium and low groups (3.6 and 3.2, respectively, per 1000 hours). This result is consistent with previous findings in a variety of sports[31,32] but in contrast with researchers[25,33] who showed the opposite (lower injury risk corresponding to higher TL). These conflicting results may be due to a variety of methodologic factors, including low sample sizes and different injury definitions and statistical approaches. However, we also demonstrated that the injury incidence rate in relation to the TL depended on the calculation method used. Most previous authors have used group data to create TL categories. For example, a study participant was placed in the high, medium, or low category based on the TL completed by the whole group. Nevertheless, no rationale exists for using the group TL as a reference. Given the individual nature of injuries, it would be reasonable to use individual data for categorization: that is, placing the individuals in the high, medium, or low category based on their TL range. To our knowledge, only 1 group[34] categorized TL using individual data (from cricket players). Interestingly, when we used individual TLs, the Med-Inj rate was opposite in direction to the group TL injury rate, with dancers in the highest TL category experiencing lower injury rates. Therefore, a clear association of TL level and injury rate was not present, which is consistent with earlier findings of both higher and lower injury risks associated with a high TL.[26] Differences in categorization methods, low sample size, and sparse data bias may explain the inconsistencies among these works[9] and support the need for larger, hypothesis-driven studies to avoid results that simply reflect "statistical noise" and potentially false discoveries.

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Illness and Training Load

High TL has been proposed as a risk factor for illness in athletes.[4–6] Changes in internal and external TL have been associated with an increased risk of illness.[8] For example, increases in training volume have been related to an increased risk of illness in elite swimmers[4] and elite junior tennis players.[5] Additionally, in team sports, increased training intensity preceded the development of URTI symptoms.[6] In our study, participants in the high and medium TL groups had the highest illness incidence rates (3.9 and 3.4, respectively, per 1000 hours) compared with the low TL group (1.8 per 1000 hours). The high TL group also experienced the longest duration of URTI symptoms compared with the medium and low groups. Still, it is difficult to compare these results because of possible variations in methods, participants' characteristics, and travel schedules. Also, many factors other than exercise affect the immune system. For example, poor nutrition, smoking, alcohol consumption, mental stress, and lack of sleep have all been associated with the impaired immune function and increased risk of infection.[35] Regardless of the underlying cause of the URTI, a major concern, other than the health effect, is the accompanying fatigue that can limit or prevent training.[36] Future researchers should adopt multifactorial preventive strategies that may include clinical, training, or lifestyle modifications.[24]

Similar to our injury results, when individual TLs were used, the illness rate was in the opposite direction to the group TL illness rate, with dancers in the highest TL category experiencing lower illness rates. Therefore, depending on the categorization method, the findings in relation to TL will be different. Without a strong rationale or conceptual framework for deciding the best way to categorize TL, no conclusion can be drawn from the current study. Thus, future investigation is warranted to develop a conceptual framework that may explain particular causal phenomena and provide a basis for interpreting results.

This study had several limitations. The sample size was restricted to the number of participants in the dance company. Accordingly, our goal was descriptive, and associations between TL and illness and injury were explored to show the dependence of the results on the categorization criteria. Although previous authors[28,29] have used similar sample sizes and numbers of events, we believed this would provide unreliable results and would not satisfy the requirements for such a study[9] that should also take into account the multifactorial nature of injuries and illnesses. However, these results increase the body of knowledge with which to create causal structures that can be verified in the future.

The main aim of our study was to contribute to the body of knowledge used to identify potential mechanisms and prognostic factors. Yet from a practical point of view, our results suggest that a possible area of intervention is TL distribution by applying training principles. Indeed, few recovery periods occurred within and between macrocycles (weeks) as shown in Appendixes B and C (mean daily and weekly TLs). Considering that professional dancers may need to undertake high TLs to achieve optimal performance, modifying the TL distribution and including recovery days and short periods of reduced load are potential immediate interventions. Furthermore, understanding the TL distribution may require monitoring strategies,[37] as well as injury and illness surveillance systems. Dancers' stoic natures and strong work ethics (eg, the desire to continue to work despite illness) may mean that practitioners need to carefully monitor the illness incidence and actively modify TLs accordingly.

Recommendations for Future Research

Our aim was to provide details on the nature and incidence of injury and preliminary information on illness occurrence. These results together with the TLs experienced by the dancers can be used to develop and hypothesize an etiologic framework and hence a causal structure (eg, directed acyclic graph).[38] This is necessary if the goal of future observational studies, as is common in sport and clinical settings, is to manipulate a variable to alter the likelihood of an event (eg, injury or illness). Although causal inference from observational studies inevitably does not ensure causation (ie, experimental studies are needed), it would provide some support to a causal link and, if strong enough, may support interventions. The variety of injury types and natures in this cohort also indicates that even though the final mechanical causes are likely similar (stress and strain superior to the strength of the structure), the antecedent causes may be different. Combining all injuries to determine associations with TL is not a reasonable approach because it would assume the same causal path for all injuries experienced by the dancers. No relation between TL and injury and illnesses could be demonstrated, but this association is worth exploring using appropriate statistical methods and sample sizes. Therefore, other than a conceptual framework to develop a causal structure, multicenter studies are necessary. Furthermore, prediction models for risk stratification (that do not require causation) are also warranted.

CONCLUSIONS

Professional dancers experienced high TLs relative to other athletes and concomitantly high injury and illness incidences and risks. Interestingly, these dancers missed very few performances, despite injury and illness. In addition, they continued training, albeit with modifications, even when affected by Med-Inj or illness. Collectively, this suggests that dancers persist with training and performance despite injury and illness, which may reflect their high level of commitment. However, the health of dancers should be a priority and the development of preventive interventions and educational initiatives encouraged.

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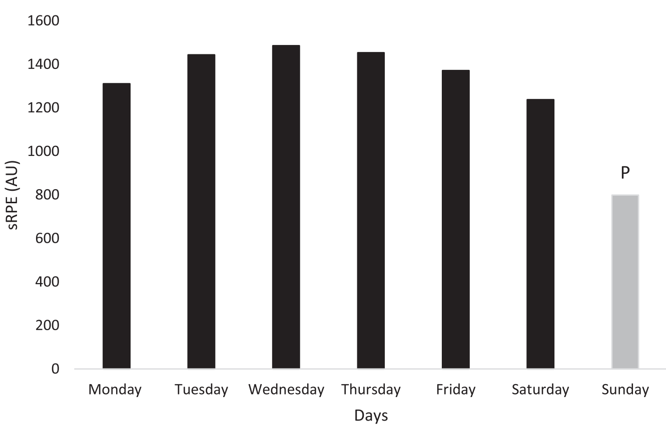
Address correspondence to Annie C. Jeffries, BSES (Hons1), MCEP, Human Performance Research Centre, Faculty of Health, University of Technology Sydney, 15 Broadway, Ultimo Sydney, NSW 2007 Australia. Address e-mail to Annie.Jeffries@uts.edu.au.

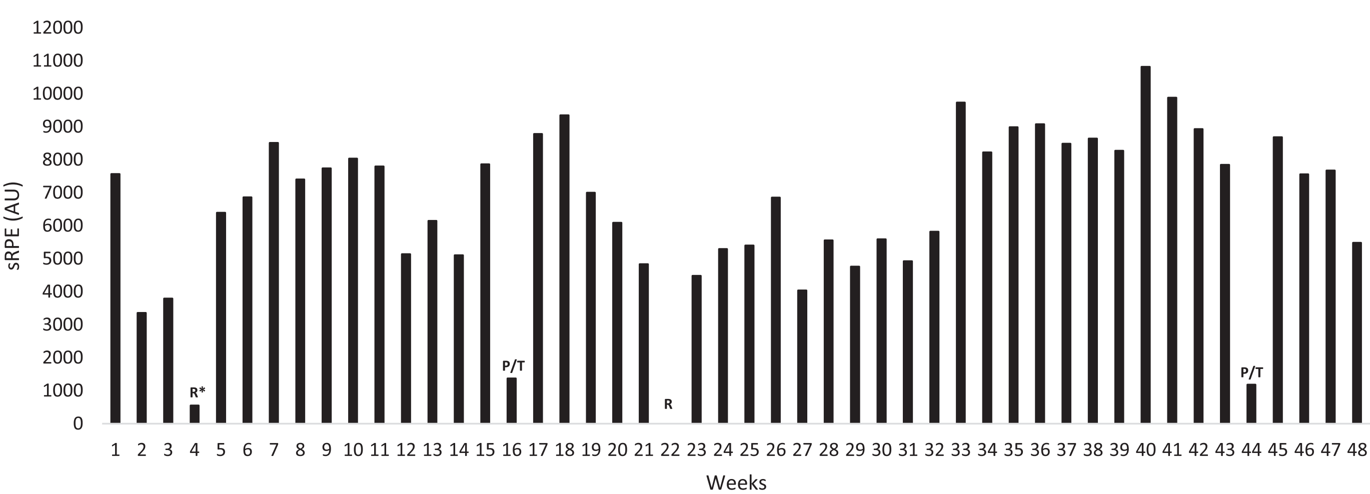
Appendix A. Mean Session Ratings of Perceived Exertion (RPE) and Duration

Session	Rating of Perceived Exertion[a]	Duration, min (Mean ± SD)
Ballet	5.5 ± 1.4	5.5 ± 1.4
Contemporary	5.0 ± 1.4	73.4 ± 8.3
Rehearsal	5.2 ± 1.9	109.6 ± 34.1
Performance	8.0 ± 1.4	84.9 ± 34.1

[a] Borg category ratio 10 scale (0 = *no exertion at all*, >10 = *absolute maximal exertion*).



Appendix B. Mean Daily Group Session Ratings of Perceived Exertion (sRPE)-Based Training Load. Abbreviations: AU, arbitrary units; P, performance only.



Appendix C. Mean Weekly Group Session Ratings of Perceived Exertion (sRPE)-Based Training Load. R: rest. R*: week 4, 1 dancer continued rehabilitation and training. Abbreviation: P/T, performance/travel.

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