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# Sleep Disturbances, Sleep-Related Impairments, Dance Exposure, and Injury Risk in Collegiate Dancers

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## Abstract

**OBJECTIVE:** Increased athletic participation affects Sleep Disturbances(SD) in athletes. Following nights with SD, professional dancers noted Sleep-Related Impairments(SRI) (i.e. low speed and concentration). Whether SD and SRI are associated with injury and exposure in collegiate dancers remains unclear Thus, we examined(1) the relationships among SD, SRI, dance exposure hours(DEHr), and injuries and(2) differences in SD, SRI, and DEHr during injured and non-injured months in collegiate dancers over 7 months.

**METHODS:** Seventy-two dancers completed the Patient-Reported Outcomes Information System(PROMIS) SD and SRI 8a short forms at the start of every month(September 2019-March 2020) describing their SD and SRI during the past 7 days of the previous month(August 2019-February 2020). A DEHr was recorded as 1 hour of dance participation in class, rehearsal, or performance. Injuries were defined as any condition where the dancer sought medical attention.

**RESULTS:** Dancers participated in 467.8±45.7 DEHr/dancer, with 14 dancers suffering 18 injuries(IR=0.53/1000-DEHr; 95% CI:0.29-0.78). The dancers' SD and SRI were higher than the collegiate athletic population(SD: $t(71)=26.3$, $p<0.001$; SRI: $t(71)=2.60$, $p=0.01$). December SD was negatively related to October, January, and February DEHr(all: r=-0.30, range: p=0.02-0.04). November injuries were negatively related to September, October, December, and January SD(range: r=-0.30 to -0.04, range: p=0.003-0.01). SD and SRI did not differ between injured and non-injured months(SD: $t(13)=0.12$, $p=0.91$; SRI: $t(13)=0.36$, $p=0.73$; while, DEHr was higher during injured months($t(13)=3.79$, $p=0.002$).

**CONCLUSIONS:** Although dancers experienced sleep disturbances and sleep-related impairments, inconsistent relationships existed among SD, SRI, DEHr, and injury in collegiate dancers. Despite injury, dancers' SD and SRI remained similar during injured and non-injured months, while DEHr was higher during injured months. Future researchers should examine relationships among SD, SRI and dance exposure over longer time-periods to clarify if these factors are related and whether sleep affects injury risk in collegiate dancers.

**Keywords:** PROMIS; Sleep patterns; Performing arts; Injury; Impairment

## Introduction

Over 300 colleges and universities in the United States alone offer dance programs, with Athletic Trainers (ATs) providing care at several of these dance programs [1, 2]. Similar to athletics, dance is a physically demanding activity, requiring aesthetic expression, muscular strength, flexibility, balance, and endurance to participate successfully without getting injured [3, 4]. While there is limited research on injury epidemiology at the collegiate dance setting, researchers have reported an injury prevalence range of 63.6-86.5% and an injury rate range of 4.89-9.3 injuries/1000 hours in collegiate dancers, noting that participation in dance has a risk of injury [5–9]. Dance exposure hours may differ depending on the dancers' performance level (i.e. pre-professional, collegiate, professional) and style (i.e. ballet, modern, Irish dance) [5–7, 10, 11]. Previous researchers note a positive relationship between the amount of dance exposure and injury likelihood in professional and pre-professional dancers (i.e. the more exposure an individual encounters, the more likely he/she is to being injured) [7, 10–12]. Others have analyzed total dance exposure over a weekly or monthly basis, or complete performance season, to gain a better understanding of temporal fluctuations in a season and its effect on injury incidence [7, 8, 10]. Still, other factors may have a more direct impact on injury incidence.

Researchers have begun to examine the implications of poor sleep quality and sleep hygiene practice on performance and recovery in athletics and dance. Similar to athletes, sleep is important for dancers as they endure both psychological and physical stress [17–19]. Multiple studies have reported that variability in training and competitions evoke sleep disturbances (SD) (i.e. worry, increased muscle tension, pain, etc.) in athletes and dancers. Furthermore, some studies have discovered that SD may lead to sleep-related impairment (SRI) in cognitive performance and mood response. For example, following nights with disturbed sleep, professional ballet dancers reported SRI low cognitive speed and concentration before a premiere. While athletes have experienced increased fatigue, altered pain perception, depression, and decreased cognition from SD. There is conflicting evidence on the relationship between sleep and injury in athletics. One study found that chronic low sleep quality affected postural control in healthy adults. Thus, a decrease in motor function could impact the likelihood of injury. Some researchers have reported that decreased sleep increases the likelihood of injury in adolescent athletes. However, others described no relationship between injury and decreased sleep. In dancers, researchers have found that psychological distress (i.e. poor sleep, increased stress, etc.) increased the likelihood of injury in their dancers. Yet others found that dancers previously injured during the last 3 years had poorer sleep compared to non-injured dancers.

Overall, limited information exists describing the relationships among SD, SRI, dance exposure, and injury in collegiate dancers. Thus, our purposes were to examine the relationships between sleep disturbance (SD), sleep-related impairment (SRI), dance exposure hours (DEHr), and injuries and (2) differences in SD, SRI, and DEHr during injured and non-injured months over 7 months in collegiate dancers.

## Methods

### Participants and Informed Consent

Seventy-two collegiate dancers (58 female, 14 males; 19.7±1.4 years, 164.5±7.1 cm, 61.3±7.6 kg) in a single convenience cohort participated in the study. The local Institutional Review Board approved the study and all participants signed informed consent forms before taking part in the study. <IRB BLINDED>

### Sleep Quality, Dance Exposure, and Injury

The Patient-Reported Outcomes Measurement Information System (PROMIS) Sleep Disturbance (SD) and Sleep-Related Impairment (SRI) instruments assess qualitative aspects of sleep and wake function [31]. The SD instrument assesses self-reported perceptions of sleep quality, sleep depth, and restoration associated with sleep, including perceived difficulties and concerns with getting to sleep or staying asleep and satisfaction with sleep [32]. The SRI instrument assesses self-reported perceptions of alertness, sleepiness, and functional impairments during waking hours associated with sleep problems or impaired alertness [33]. We utilized the Adult 8a short forms of the SD and SRI (Table I). The surveys were administered at the beginning of each month for 7 months (September to March) using a web-based survey Qualtrics (Provo, UT). The scores reported during each month described the dancers' SD and SRI over the last 7 days, which corresponded with the last week of the previous month (August to February). A DEHr was defined as one hour of dance participation in class, rehearsal, or performance. Class was defined as the dancers' regular modern and/or ballet technique class. Rehearsal was non-class time devoted to a later performance (i.e. residency, student pieces, etc.). Performance was defined as the participation in choreographed pieces during a show over one or multiple days. Injuries were defined as any condition where the dancer sought medical attention.

### Statistical Analyses

Descriptive statistics (M±SD) of DEHr, SD, and SRI were calculated. SD and SRI raw scores were converted to T-scores using the PROMIS Health Measures Scoring Service (https://www.assessmentcenter.net/ac_scoringservice). The T-scores rescale the raw scores with a mean of 50 and standard deviation of 10. Higher T-scores display more of the construct being measured. Thus, a T-score higher than 50 indicate worse SD or SRI. While T-scores lower than 50 indicate better SD or SRI. An overall injury rate (IR) was calculated using the IR formula. Total SD, SRI, DEHr, and injuries were calculated using the sum of their respective scores and numbers from August to February. For injured dancers, their SD, SRI, and DEHr were separated into non-injured and injured months, with the average taken of the months.

Formula: IR=(total number of injuries)/(total DEHr) x 1000

A one-sample t-test examined whether the dancers' SD and SRI scores differed from the collegiate athletic population (SD: $\mu$=50.4, SRI: $\mu$=53.9). Pearson correlations examined the relationships among Total and monthly SD, SRI, DEHr, and number of injuries. Dependent t-tests determined differences between injured dancers' average SD, SRI, and DEHr during injured and non-injured months ($p<0.05$). The statistical software SPSS 25.0 (IBM Corp, Armonk, NY) was used to conduct all analyses.

## Results

Fourteen dancers suffered 18 injuries, and a 0.53/1000 DEHr IR (95% CI:0.29-0.78) (Figure I). Dancers (n=72) participated in 33,679.9 total DEHr – for an average of 467.8 ± 45.7 DEHr/dancer over the 7-month period. Monthly SD, SRI, DEHr, and injury are displayed in Figure II. The dancers' SD and SRI were significantly higher than the collegiate athletic population (SD: $t(71)=26.3$, $p<0.001$; SRI: $t(71)=2.60$, $p=0.01$).

## Discussion

### Primary findings

Sleep disturbance, sleep-related impairment, dance exposure, and injuries were inconsistently related over the study period. Although the dancers experienced SD and SRI, these factors did not differ greatly once dancers got injured.

### Sleep and dance exposure

Overall, the dancers participated in ~20 DEHr weekly throughout the semester. Previous researchers have reported a range of DEHr in the pre-professional and collegiate dance settings, with our dancers' ~20 hours weekly placing in the upper end of the range (range: 7.9 – 30.3 DEHr/week). Furthermore, our dancers experienced SD and SRI every month (Figure II). In comparison to the collegiate athletic population, the SD and SRI scores in the current study were higher. To our knowledge, there is only one study utilizing the PROMIS SD and SRI with athletes [35]. Thus, additional research is needed using the PROMIS SD and SRI measures in dancers and athletes to understand SD and SRI in these populations. Previous literature describes conflicting views on the relationship between exposure (i.e. volume) and sleep [16, 30]. Prior authors reported no relationship between increases in weekly or monthly load and sleep quality or quantity. Others note that increased exposure affected professional dancers' sleep quality, sleep duration, time in bed, and wake after sleep onset. However, the authors suggested that anxiety and fear of injury were responsible for these observations. Still, different researchers found that increased training led to decreased sleep quality in functional overreached athletes. In contrast, the present study found mixed results when examining the effects of dance exposure on SD and SRI. Still, it is important to recognize that in addition to DEHr, other factors such as academic work (i.e. examinations, deadlines), social interaction (i.e. friendships, drinking), mental health, and the environment (i.e. house temperature) could have influenced the current study's SD and SRI findings. For example, previous authors found that college students reported SD and SRI scores averaging 54.4 and 60.0, respectively [40]. While others reported that collegiate student athletes experienced poor sleep quality, increased daytime sleepiness, and obtained insufficient sleep [39]. Therefore, further

research is needed to understand the relationships between quality of life (QoL), exposure and sleep in the collegiate dance population.

## Sleep and injuries

Overall, our dancers suffered 18 total injuries (IR= 0.5 injuries/ 1000 DEHr) (Figure I), which is much lower than previous reports in Irish highland and collegiate contemporary dancers (IR=8.4 - 10.6 injuries/1000 DEHr) [8]. In this study, the dancers experienced the most injuries in September (n=7) and November (n=7) (Figure II). Surprisingly, injuries did not seem to affect the dancers' sleep during a week in the same month. For example, there was no relationship between September injuries and SD or SRI during a week in September. Instead, November injuries were negatively related to SD during one week in September, October, December, and January. Typically, one of the consequences of injury is pain. Previous studies have shown that pain affects sleep [23, 24, 41]. Furthermore, chronic pain has been commonly associated with sleep disturbance and insomnia [23, 42, 43]. However, there is conflicting evidence on the directionality of the relationship between sleep and pain. Some authors have found that pain influences sleep disturbance, while others have discovered the opposite [43]. However, despite 57% of the November injuries being chronic in this study, the dancers' SD and SRI were not negatively affected. Thus, the nature of injury may not be the sole contributing factor to SD. Further research is needed to determine the level of influence the severity and nature of injury, and/or the individual's pain tolerance have on dancers' sleep.

The total number of injuries were negatively related to December and January SD, and positively related to December SRI. This finding could be due to the decrease in exposure hours as the dancers were leaving and returning from winter break. Surprisingly, during non-injured and injured months, the dancers' SD and SRI stayed similar. This finding contradicts a prior study which found that dancers with an injury during the past 3 years suffered worse sleep than uninjured dancers. Others found that their athlete's sleep quality improved from being injured to healed [44]. Typically collegiate dancers or athletes may suffer from SD and SRI at the end of the semester for a variety of reasons: (1) they might have been stressed and anxious because of final performances and examinations, (2) had not fully recovered from a previous injury but felt pressure to return[19], (3) continued to have pain, (4) been depressed, or (5) been fatigued after a long semester. In our study, it seems that other factors such as psychological and social stress may have influenced SD more than physical stress (i.e. injury). In contrast, the presence of SRI may have increased the risk for injury as previous researchers reported a positive relationship between sleep problems, sleepiness and injury. Further research is needed to understand the impact of changes in QoL, SD, and SRI on injury risk in dancers.

## Injury and dance exposure

Interestingly, January injuries were negatively associated with Total DEHr. We speculate that towards the end of the fall semester, the dancers' DEHr decreased as a result of performances and winter break, which may have reduced the number of injuries. A previous study reported that the number of injuries decreased as the year progressed, despite steady exposure. Lee et al found that the total number of dance exposures was more associated with injury risk compared to DEHr in pre-professional dancers. The above finding is interesting as DEHr typically provides a more precise understanding of a dancer's load compared to dance exposures. A possible explanation for an association between the number of dance exposures and increased risk of injury is that injury risk may be more associated with the intensity of the load versus the volume of load. In contrast to the above study, prior researchers have reported that in pre-professional dancers, injury risk increased with increases in DEHr. Bronner et al[10] found there was a higher rate of injury during a period in the season with more DEHr in professional modern dancers. Cahalan et al[8] reported that contemporary dancers suffering a time-loss injury described participating in more hours of dance a week prior to the injury. Lastly, professional ballet dancers participated in an average of 34 hours a week resulting in a mean injury rate of 6.8 injuries per dancer per year. Despite DEHr being higher in injured months compared to non-injured months, DEHr and injury were not positively related in the current study. One possible reason for this discrepancy is that our dancers may be fit enough to dance 20 hours weekly without negative effects on their body. Alternatively, a prior study has suggested the existence of a training paradox where elevated load is protective up to a point, and excess load can increase the likelihood of injury. While there is no current suggested limit on DEHr, the International Olympic Committee suggests that athletes restrict weekly increases in training load to <10% or sustain an acute:chronic ratio within the range of 0.8-1.3. Still, future research is needed to examine how much DEHr is excessive and increases risk of injury in collegiate dancers.

## Sleep measures

As mentioned earlier, the PROMIS SD and SRI instruments are qualitative measures that assess sleep quality and impairment [32, 33]. The PROMIS SD and SRI instruments were administered for various reasons – 1) the instruments have a 7-day recall period (i.e. able to distinguish weekly fluctuations), 2) various forms of length and populations (i.e. SD: 4a, 6a, 8a, 8b; adult, pediatric, parent proxy versions), and 3) the SRI instrument provides information about functional impairment as a result of sleep problems, not just sleepiness. Still, we recognize that there are other sleep instruments used in athletics and dance that are reliable and valid (i.e. the Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), and Athlete Sleep Behavior Questionnaire (ASBQ)). Although the above sleep measures examine valuable information, these measures are limited in their scope by only looking at sleep disturbance or daytime sleepiness. While it is important to understand that athletes and dancers are disturbed during sleep, it is equally important to understand the possible functional impairments that result from disturbed sleep. The ESS is adequate in assessing daytime sleepiness, but it does not record the possible decrements in function as a result of disturbed sleep. Thus, in this study, the authors believed that the PROMIS SD and SRI instruments were the most appropriate options to investigate SD and SRI in collegiate dancers. We suggest future work with the diverse sleep measures in dancers.

The PROMIS SD and SRI surveys do not ask for quantitative sleep data (i.e. time it took to get to sleep, how many times did they wake up, etc.) and this could be good information to examine in the future. We administered the surveys at the start of the month as this helped with compliance and allowed us to understand dancers' sleep patterns over the last 7 days of the previous month. However, as the surveys were only administered once per month and describing the past 7 days, we were not able to examine daily, weekly, or monthly fluctuations in sleep patterns. Future researchers should attempt to examine dancers' sleep multiple times over a month to investigate more phasic sleep fluctuations, especially before and after performances or other

important events. We acknowledge that the PROMIS instruments were developed utilizing the general population and its use has not been validated with the athletic population. Subsequently, the current sleep scores may over-identify sleep disturbances and sleep-related impairment in our dancers. Specifically, the SRI forms were evaluated on chronically ill patients [33]. Thus, the mean of 50 on the SRI instrument describes sicker people than the general population [33]. Lastly, many collegiate dancers serve as dance teachers at private studios or participate in dance choreography outside of the university. However, we were not able to collect this additional dance exposure information. Thus, if feasible, we suggest researchers collect all dance exposure (i.e. university and outside exposure). Despite the exclusion of non-university dance exposure, the dance exposure included in this study still provide valuable information as to the volume of dance that collegiate dancers participate in over a 7-month period. We recommend that future studies include (1) the examination of QoL (i.e. psychological, social, and physical health) and sleep to understand its impact on injury in collegiate dancers, and (2) the utilization of athlete-specific questionnaires to identify differences between scores on validated general population and athlete-specific questionnaires. However, if athlete-specific questionnaires do not provide adequate information about dancers' sleep, the creation of a dance-specific sleep instrument may need to be discussed.

## Conclusion

Overall, we found inconsistent relationships between SD, SRI, DEHr, and injury in collegiate dancers. SD and SRI were similar during injured and non-injured months; however, DEHr was higher during injured months. Also, 20 hours of weekly dance-related activity does not seem to negatively impact sleep in collegiate dancers. Future researchers should investigate how SD, SRI, dance exposure, and quality of life (burnout, fatigue, mental health) influence injury risk in collegiate dancers.

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