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Exploratory Characterization of Injury in Recreational Aerial Circus Arts

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Aerial arts are growing in popularity as a hobby. They may be perceived as risky or dangerous, but there is no research to provide evidence of these assumptions. This study aims to provide information about the frequency and nature of injuries among practitioners of aerial circus arts. This longitudinal mixed-methods survey collected data from 98 adult recreational aerial arts students over four months. Using a purpose-designed survey, the participants, aged 20 to 54, reported 63 injuries among 44 students occurring over an average of 4,603 class hours to generate an injury rate of 13.70/1,000 mean hours of class and a medical attention injury rate of 4.13/1,000 mean hours of class. Descriptive data about the injuries were also collected to compare with other studies on recreational sports injuries, circus performing artists and professional program training data. The results indicated areas of interest that could be a focus for further research and instruction, such as shoulder and arm health, mat usage and selection, clothing selection and whether underlying conditions related to hypermobility pose additional risk. The results corroborate and expand previous research on professionals and professional training programs to include recreational students in the types of injuries sustained by aerial arts participants.

Introduction

Aerialists on social media eagerly show off their latest tricks and skills, which are often perceived by the uninitiated as dangerous. However, there has been little research to demonstrate how often injuries and accidents occur in recreational aerial arts classes. This results in speculation and assumptions about the level of risk compared to other sports and fitness activities, with little data to provide a meaningful comparison.

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Historically, only a small amount of research has been published on circus arts in general, with very few studies on injury incorporating aerialists. In addition, many of the studies that included aerialists focused specifically on performing circus professionals or pre-professional training programs.[1–10] The current crop of studies was prefaced by a 2009 study that analyzed five years of Cirque du Soleil medical data with an injury rate of 9.7 injuries per 1,000 performances as exposures.[6] Researchers determined that the overall injury rate among performers was similar and often lower than in other sports, including women's gymnastics. Another similar ten-year study focusing on injury prediction showed an injury rate of 5.1/1,000 performances, with 89.4% of performers experiencing an injury during the study period.[7] Both studies used data taken from medical records collected by their respective organizations. The use of medical and/or insurance records for data has been repeated in other circus-specific studies, including a study that used worker's compensation data for German circus students[10] and other studies that used physiotherapist data from one Australian circus school[5] and one Canadian circus school.[9] Additional studies have utilized a variety of data collection methods beyond medical records, including qualitative interviews[1,2] and prospective surveillance.[3,4]

There has been some exploration of injury in general adult recreational fitness by direct participant reporting, including a pair of studies from the 1990s that attempted to quantify injury in a variety of fitness activities.[11,12] These studies established that despite some challenges, direct survey of participants offers valuable insight into evaluating injury rates for recreational activities. In another recently published study, researchers explored the injury rates and types of injury in recreational and professional sport pole dance as determined from a survey of participants.[13]

There are other practical challenges to generating meaningful injury or risk prevention data within the dynamic and varied environments of sports or performing arts.[14–17] Mixed methods and qualitative studies provide an expanded opportunity for insight into injury and risk in circus arts that has not been uncovered in quantitative studies. The method of collection impacts how injury is defined and can be measured, as well as what data will be captured. Conventional modes have been injuries resulting in a need for medical attention or time loss affecting performance/work/training.[3,15,18,19] Both medical attention and time loss, in addition to other information, can be captured as reported directly by a participant. However, a complete picture of injury is still more complicated.

The challenges presented by attempting to produce meaningful, robust injury data have been explored in the 2020 International Olympic Committee (IOC) Consensus Statement,[20] as well as a subsequent circus-specific extension published in 2022.[21] These statements establish standards for categories of injury involving specific body parts, tissue types, relationships to activity, modes of

onset and types of contact. They also establish conventions for evaluating severity with data collected from healthcare practitioners and the circus participant. Although the extension to the IOC methods was published after data collection for this study had already concluded, this development shows promise for encouraging the collection of more data that can be readily compared.

With no previous research on recreational aerial students, it is impossible to go beyond speculation of injury risk. Therefore, this study seeks to determine how often adult recreational aerial students get injured while participating in the activity, what types of injuries are occurring and whether there are any trends of injury to guide safety practices. It also presents an opportunity for comparison with professional training programs and other recreational sports or activities to provide a more informed evaluation of risk.

Methods

This study was a four-month longitudinal mixed-methods retrospective survey. It was conducted using all best practices for human subjects in accordance with the Declaration of Helsinki, and international approval was granted by the Institutional Review Board of Concordia University, St. Paul.

Participants

All participants were over eighteen years of age and taking at least one instructor-led aerial arts class per week. An aerial arts class was defined as involving trapeze, silks, rope, Spanish web, hammock or sling, Lyra and/or other aerial apparatus. Current professional performers and those set to become professionals within one year, as self-indicated, were excluded because the training intensity and difficulty of skills performed by those individuals could potentially exceed a recreational capacity of practice. Participants were not excluded for disease or other co-morbidities in order to maintain a more accurate representation of the population, as recreational students may not be excluded from classes due to underlying conditions.

Recruitment was done using social media and by direct outreach to professional organizations and schools offering aerial arts classes, with initial consent enrolling 282 participants. However, many individuals who completed the initial consent did not meet the inclusion criteria for a variety of reasons, including professional status, not participating in instructor-led classes, or exclusive participation in activities not covered by the scope of this survey, such as pole or ground acrobatics. The number of eligible participants who started the study

was 193. Ninety-five participants did not complete all of the four monthly surveys, resulting in a 49.22% participant attrition. The final data set represented 98 participants.

Survey

In the absence of a validated instrument, the survey was designed for this study and kept brief to encourage participation. It incorporated basic demographic data on age, gender, apparatus and years of experience. It also included weekly exposures based on hours spent in class.

The survey asked participants to answer "yes" or "no" to whether an injury had been sustained in the previous month, and whether the injury occurred during or in relation to aerial classes. If they answered "yes," there were additional questions asking about the type of injury, treatment status, number of missed classes or workdays, reoccurrence, and any environmental or equipment factors related to the injury. In an open-ended question, the participants reported care including general practitioners, emergency care, critical care, dermatology, orthopedic surgeons, physical therapists, physiologists and a medic. The survey also asked whether any alternative treatments were used. Please see Appendix One for the complete survey questions. The addition of qualitative questions allowed for an exploration of the nature of the injuries, including causes and types of injuries. All data, as well as the definition of injury, were self-defined by the participants since recreational aerial arts facilities do not often have medical personnel, and students may have a range of access to healthcare. Since injury and healthcare as concepts vary between individuals, this allowed for better expression of the individual injury experience. This survey version was assessed before use by two industry experts to eliminate bias.

Administration and analysis

The survey was administered over the Internet using Survey Monkey (www.surveymonkey.com). Initial rolling enrollment and consent occurred between 28 January 2022 and 26 February 2022. Participants who provided informed consent and met the inclusion criteria were sent a monthly email with a link to the web-based survey for the following four consecutive months. A reminder email was sent a week prior to the end of the monthly collection, with the final data collection closing on 10 June 2022.

After all data had been collected, they were compiled and inspected to eliminate incomplete and duplicate replies. Two researchers used inductive methods

to code the qualitative data independently and assign categories of injuries. They also established themes with mutual agreement on the results. Frequencies, averages and standard deviations were calculated using SPSS software version 28 (IBM, Armonk, NY). Since class length is not standardized across venues, participants selected a range of hours (e.g., 1–2, 2–3) in the survey to represent their exposure to aerial classes for that month. Both the high and low possibilities of a range were multiplied by 4.5 to calculate a high and low potential of class hour exposures per month. The mean of the range was used to generate an injury rate per 1,000 mean class hours. The research goal was to create data which could be compared to previous studies.[3,6,11,19,22]

Categories of injury

The injuries were coded and categorized based on whether the type of self-reported injury was a musculoskeletal injury (MSK) or a superficial tissue or skin injury (S). Even with the data collection and study occurring before the 2022 circus-specific extension of the IOC Consensus Statement was released, the results could be re-coded to the recommended categories based on bodily regions.[20,21] The MSK category is broad and includes the IOC working group tissue categories of bone, muscle/tendon, cartilage/synovium/bursa and ligament/joint capsule.[20]

Results

The complete sample included 98 international participants. Seven participants changed their professional status during the study, but their data were still included based on their recreational status at baseline. The participants primarily identified as female (90%); four identified as male, and five identified as non-binary. Seventy-eight percent of the participants were from the United States. Other participants resided in Canada, Australia, Ireland, New Zealand and Singapore. See Table 1 for participant demographics.

Of the final 98 participants, 54 reported an injury of any kind, and 44 reported aerial class-related injuries over the course of a consecutive four-month study period. There were 63 separate aerial class-related injuries among 44 participants. As reported by the participants, the total class hours over four months ranged between 3,780 and 5,427 hours (mean 4,603.5). The estimated injury rate was 13.70 injuries per 1,000 mean hours of class. The injuries were classified by the descriptions given and grouped by body part (Table 2). The majority were in the larger grouping of MSK injuries, including self-identified sprains, strains, dislocations, joint pain, soreness and a single wrist fracture. Twenty injuries had

Table 1. Participant Characteristics

Characteristic	**n**
Gender	
Female	89
Male	4
Non-binary	5
Country	
United States	76
United Kingdom	9
Canada	8
Australia	3
New Zealand	1
Singapore	1
Experience (Years)	
<1	10.25
1-2	8.75
2-3	14.75
3-4	20
4-5	11.75
>5	32.5
Hours of Class per Week*	
<1	3.75
1-2	41.25
2-3	21.25
3-4	18.25
5-6	10
>6	2.75

Note: N=98. Participants were, on average, 35.57 years old (SD = 8.84).
***Not whole numbers due to variations in survey responses across the study period and/or null responses.**

elements of superficial injuries, including bruising, burns, abrasions and tears of the skin. Ten of the injury reports spanned multiple bodily regions and/or categories of injury.

Of the participants, five mentioned the involvement of the head or neck. The upper limbs were involved in 34 injuries, the trunk in nineteen and the lower

Table 2. Categories and Location of Injuries

Category	Part	MSK	Skin*	
Head/ Neck Area				
	Head	0	2	
	Neck	3	0	
Upper Limb				
	Shoulder	15	0	
	Upper Arm	0	3	
	Elbow	5	0	
	Forearm	1	0	
	Wrist	8	0	
	Hand	5	1	
Trunk				
	Chest	3	1	
	Thoracic Spine	6	1	
	Lumbosacral	5	3	
	Abdomen	1	0	
Lower Limb				
	Hip/Groin	1	1	
	Thigh	1	2	
	Knee	1	4	
	Lower Leg	0	0	
	Ankle	2	1	
	Foot	0	1	
Multiple Regions	# regions= # instances	2 = 7	3 = 1	4+=2

***Note: Totals exceed injury instances due to the inclusion of multiple injury regions.**

limb in eleven. These numbers will not add up to the same numbers represented in Table 2 due to multiple areas of the category being mentioned in the injury description. For example, if a participant reported a single incident of pain in

their forearm and wrist, it would be represented twice in Table 2 but only once in the larger category of "Upper limb." In addition, the injuries are classified as described by the participants and not generated by medical personnel; thus, there was a variety of technical depth in the descriptions.

Treatment

Nineteen of the injuries among seventeen participants resulted in the participant seeking medical attention. Seven participants with injuries described seeking alternative therapies, including bodywork, chiropractic care, myofascial release, massage, physical therapy exercises, acupuncture, cupping and herbal supplements. It is important to note that "physical therapy exercises" may be better defined as medical care rather than alternative treatment. The instance of injuries that received medical attention, not including alternative therapies, was 4.13 injuries per 1,000 mean hours of class.

Time loss

Only five injuries were severe enough to prevent the participant from finishing class. Thirty-five participants continued class, and nineteen participants continued class with modified activities. Only two of the reported injuries resulted in time loss from work in unknown occupations totalling 3.5 workdays. The data on subsequent missed classes were not included, as they were inconclusive due to some participants answering with more missed classes than they would have attended during the survey period.

Other findings

Forty-three of 63 injuries were reported to the instructor. Twenty of the injuries were attributed to a pre-existing injury or condition, and two participants indicated that the injury was "possibly" attributed to a pre-existing injury or condition. Participants mentioned conditions such as previous injury, chronic pain, fibromyalgia, hypermobility and Ehlers-Danlos syndrome (EDS) as potential contributing factors in at least three instances.

Contributing or environmental factors described by participants who experienced an injury were diverse. Clothing was attributed to at least seven of the injuries. Mat size or placement was mentioned in at least five of the injuries, including the only bone fracture in the data. Responses from other participants

mentioned poor judgment or insufficient caution, insufficient warm-up, room temperature (e.g., either too hot or too cold), poor instruction and equipment changes.

Discussion

This study was intended to establish data on the frequency of injury for adult recreational aerial arts students using three primary measurements: occurrence, medical attention and time loss. It collected frequencies from survey questions that could provide more perspective on the injuries that occur to guide future research. The information provided by the participants also offered a glimpse into the complicated nature of evaluating injury with regard to severity and potential contributing factors.

Our injury rate was 13.70 injuries per 1,000 mean hours of class exposure. Shrier et al. found 9.7 injuries per 1,000 professional performance exposures,[6] and Stuckey et al. found 1.89 injuries per 1,000 professional track student training hours.[9] However, both of these studies included other types of performers in addition to aerialists and are unsuitable for direct comparison because of differing methodologies for calculating exposures. In addition, there are no known studies focusing only on recreational circus artists or aerialists to compare the data. Therefore, future investigations should be conducted to confirm and replicate the number of injuries per 1,000 hours of class in recreational aerial circus arts students.

The rate for medical attention injuries was 4.13/1,000 mean hours of class, which appears similar to a study on recreational team sport participation.[11] They found over fifteen injuries per 1,000 hours of team sports and less than five medical attention injuries per 1,000 hours of team sports.

There are other caveats to the direct comparison of injury patterns to those in previous literature. First, the participants in the current study were given the freedom to list any injury without restrictions or guidelines for severity. This means that several of the injuries may be less significant than would be documented in other injury studies. In the 2012 Wanke study,[10] insurance data were used, which would have reflected instances severe enough to be reported for claims. Similarly, other studies of circus schools[9] and professionals[6,7] used data reported by medical staff, thus reflecting injuries severe enough to require medical attention.

There may also be distinctly different expectations and perceptions between professional performers and recreational students over what constitutes an injury. For a professional performer, injuries such as skin abrasions, bruises and aches or pains may be minimized or dismissed,[2,23] while recreational students

may be more likely to recognize these as injuries. Allowing the participants of the study to define injury gave them the freedom to express their experience, even though it may have reduced the technical accuracy of the data. The ease of use of the online survey format allowed for more reach within the disparate and unknown population of recreational aerialists; it also allowed for reporting perceived complex factors influencing injury, such as described in research by Bolling et al.[1] and Cayrol et al.[2] This allowed for the inclusion of individuals with a variety of relationships to the medical industry for economic, social, or other reasons without invalidating their experience.

Some trends can be observed when looking at these data alongside other studies. In a systemic review of injury research in circus, Wolfenden and Angioi[19] found that muscle and joint injuries were most common, but studies showed few bone injuries. This is echoed in this study, with the majority of reported injuries being MSK complaints and only one broken wrist. In addition, the shoulder is frequently indicated as an area of injury.[9] The data from this study show a similar pattern with fifteen shoulder-specific mentions and 34 categorical upper limb complaints overall. Other studies of circus performers have also identified this location as an area of concern.[4,6] A recent study on pole dancing has also shown a similar prevalence of shoulder injuries.[13] This suggests that the upper extremities could be an area of special focus for injury prevention efforts. Further research should explore specific types of injuries in the upper extremities for recreational aerial students and the activities contributing to these injuries.

Skin abrasions or bruising occurred in at least eleven of the injury incidents, seven of which were on the silks and resulted in "silks burn." Note that this number is different from the total in Table 2 due to some injuries spanning multiple regions of the body. Locations of skin injuries included behind the knees, on the back and on the inner arm/armpit, with a common theme of a lack of coverage of the affected area. A frequently identified co-occurring factor was the temperature in the class setting, inclusive of both too warm or too cold, resulting in modified clothing like pants being rolled up to get more grip. Additionally, some fabrics may offer more feeling of grip, as reported by a subject who stated that they wore slippery pants. Since many of the injuries in this study were attributed to clothing, further attention is warranted as an opportunity to avoid these types of injuries.

At least five of the reported injuries within the current study named mat size or placement as a contributing factor. More specifically, mats were cited in the single wrist fracture, an ankle sprain and one occasion where a student's head hit the floor outside of the mat's cushion coverage. Since mats are the primary safety equipment for aerial arts, they are a variable that should be a key focus to ensure that they are used as effectively as possible. There is potential for future

research to explore the optimal selection, size and placement of mats in relation to various pieces of equipment and skills.

At least three injured students mentioned hypermobility and previous dislocations. Since aerial arts often highlight flexibility, this may be a popular activity for individuals with underlying conditions related to hypermobility. While they have not been conclusively found to be a risk factor, the mention of these conditions suggests that the participants may believe they put them at a higher risk for injury. To provide hypermobile individuals with safe environments for learning and performing aerial skills, instructors should be knowledgeable and aware of these conditions in addition to learning students' injury history.

Limitations

The study's limitations included the lack of a standard definition of injury. The opt-in, recall-based nature of the study, alongside the high participant attrition rate, may have skewed the results to include more or fewer participants with injuries.

The study did not have the benefit of the 2022 IOC circus-specific extension standards,[21] and incorporating medical personnel would not have been feasible. Its design did not allow for collecting data related to activity, mode of onset or types of contact, nor did it benefit from the standardized data collection forms in the IOC extension. The survey was not accessible to those without English-language skills or Internet access.

Finally, there are few controls for class pedagogy in aerial arts instruction at a recreational level. It is also acknowledged that more practitioners have access to home equipment and learn without direct supervision. This study was limited by including only individuals participating in instructor-led aerial classes, and it did not survey the participants on whether they practice independently. Future studies may explore injury and unsupervised learning environments in aerial arts to see whether the frequency and patterns of injury are comparable to instructor-led learning environments.

Conclusion

This study generated data to characterize the injuries sustained by recreational aerial arts students. It was found that medical attention injuries were not common. In addition, injuries were mainly musculoskeletal, and the shoulder/upper limb is an area of concern. There were also indications that clothing choice and mat usage may be a potential focus for injury reduction. These data may be used

to guide teaching pedagogy and explore safety policies for recreational aerial arts classes. By promoting awareness of commonly occurring injuries in the recreational population, the hope is that better injury prevention practices can be further explored and implemented.

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Appendix One - Survey Questions

Question	Response Format
Demographic Data	
Age in years	Numeric
Gender Identity	Multiple choice - M/F/Non-binary/ Prefer not to say
Country of residence	Fill in
Activity Data	
Which aerial apparatuses do you train on?	Multiple choice - choose all that apply (Static Trapeze, Dance Trapeze, Flying Trapeze, Lyra or Hoop, Silks or Tissu, Straps, Hammock or Sling, Rope, Spanish Web, Other)
How long have you been participating in aerial classes?	Categorical - >1yr, 1–2yrs, 2–3yrs, 3–4yrs, 4–5yrs, <5yrs
How many hours of aerial classes per week (non-pole, with instruction) do you attend?	Categorical - >1, 1–2, 2–3,3–4, 5–6, <6
Would you consider yourself a professional aerial performer (in the past year) or do you intend to become a professional performer in the coming year?	Y/N
Injury Data	
Have you been injured in the last month?	Y/N
Did your injury occur in or related to your aerial class(es)?	Y/N
If yes, please answer the following questions for each injury:	
Briefly describe the injury or injuries including area of body, nature of injury and activity (if applicable).	Qualitative fill in
Please list any apparatus that was involved.	Fill in

Question	**Response Format**
Was the injury reported to your instructor?	Y/N
Did you complete that class?	Y/Yes but modified/N
Did the injury result in missed class?	Y/N
How many days?	Numeric
Did the injury result in missed work?	Y/N
How many days?	Numeric
Did you seek medical attention for the injury?	Y/N
Please explain.	Fill in
Did you seek alternate care for the injury such as acupuncture, holistic medicine, chiropractor, herbalist or other care?	Y/N
Please explain.	Fill in
Was the injury impacted by a pre-existing injury or other pre-existing condition?	Y/N
Please explain.	Fill in
Please list any environmental factors that contributed to the injury (mat placement, temperature, clothing, etc.)	Fill in