

**PREVALENCE OF MUSCULOSKELETAL INJURIES AMONG WORLD CLASS**

**DRUM AND BUGLE CORPS:**

**A cross-sectional study**

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## ABSTRACT

Drum and Bugle Corps (drum corps) is an evolving and physically demanding activity that has grown in recognition over the years. Drum corps is considered a performing art as a musical marching unit consisting of brass, percussion, and colorguard sections. There are limited studies available regarding the health of marching artists, particularly those involved in drum corps. Specifically, the burden of musculoskeletal injury (MSI) in drum corps is currently unknown. Therefore, the purpose of this study was to determine the prevalence and correlates of MSI in a single drum corps participating at the World Class level in the Drum Corps International (DCI) competition circuit during the 2018 and 2019 seasons. A retrospective cross-sectional design was used to compare demographic and pre-participation variables between injured and non-injured participants. MSIs were evaluated and recorded by corps medical staff and extracted from the electronic medical record (EMR) for our analysis. MSI prevalence was summarized by season, type of injury and participant characteristics. Multiple logistic regression was used to identify demographic and pre-participation correlates of MSI. Overall MSI prevalence was 32.2% (N=149) and 26.2% (N=149) in the 2018 and 2019 seasons, respectively. Higher BMI (Adjusted OR: Obese = 0.88 [95% CI: 0.25 – 3.17]) and fewer years of DCI experience (Adjusted OR = 0.55 [95% CI: 0.37 – 0.84]) were associated with higher odds of MSI in the 2018 season. However, these factors were not associated with MSI in 2019 season. In conclusion, this study determined the MSI prevalence occurring in a World Class DCI drum corps to be considerable with substantial season variability. Lower BMI and attributes associated with more years of drum corps experience may be associated with lower odds of MSI.

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AND BUGLE CORPS: A cross-sectional study

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## INTRODUCTION

Musculoskeletal injuries (MSI) are a major public health problem that disproportionately contribute to a large burden of disability and diminished quality of life among military and athletic populations in the United States.<sup>1-6</sup> The Center of Disease Control and Prevention (CDC) has estimated 4.3 million nonfatal sports- and recreational-related injuries are seen in emergency departments annually in the United States.<sup>5</sup> The most frequent diagnoses involve strains/sprains (29.1%; 95% CI=25.2%-33.0%). The overall rate of injury in this setting is approximately 15.4 per 1,000 population, resulting in a substantial financial burden on the United States' healthcare system.<sup>3,5,6</sup>

Since 1970, MSI surveillance programs have been established predominantly by sports organizations and have standardized methods for reporting injuries. In 1982, the National Collegiate Athletic Association's Injury Surveillance System began and has since become one of the most comprehensive instruments available to track MSI in North America.<sup>7-9</sup> Although traditional sports organizations have established uniformity in tracking MSI, other physically-active populations and the medical professionals working with them lack awareness of both MSI prevalence as well as appropriate methodology for collecting MSI data.<sup>7,10,11</sup> While sports injury experts have scrutinized the influence of injury definition on injury estimates within their cohorts,<sup>12-15</sup> little research to date has been conducted within the dance and performing arts populations.<sup>12</sup>

Following injury quantification, most studies seek to establish common injury risk factors that will inform future intervention and prevention work. The risk factors which have been identified in dance populations that are most commonly modifiable include: body mass, joint range of motion, dance exposure (e.g. years of training, weekly exposure hours), and age.<sup>16</sup>



Previous history of injury and gender have also been noted as risk factors for MSI amongst pre-professional dancers, with females having a higher occurrence of having sustained a prior injury when compared to males.<sup>17</sup> Although there are some investigations of risk factors in dance, there is still a lack of high quality studies regarding their associations within this population. Therefore, the lack of high-quality research on risk factors makes it difficult to design interventions that reduce risk or promote protective effects.

Musicians are performing artists who participate in multiple hours of rehearsals, performances, and independent practice daily. Studies have found similar concerns for injuries in musicians, especially MSIs due to the physically-taxing demands of this repetitive activity.<sup>18,19</sup> Professional orchestral musicians have been found to have a 12-month injury prevalence between 62-93% and a lifetime prevalence between 52-93%.<sup>20</sup> Wu<sup>20</sup> reported prevalence of playing-related musculoskeletal disorders in musicians ranged from 39 to 87%, and a recent systematic review by Rotter et al.<sup>21</sup> demonstrated a 12-month prevalence ranging from 82% to 86% amongst the highest quality studies evaluated. Unfortunately, many of the studies investigating MSI prevalence in musicians represent MSI as retrospective, self-reported pain complaints submitted via questionnaire. These methods severely limit the clinician and researcher's ability to build on this research with further longitudinal, interventional, and outcomes studies.

Risk factors for musculoskeletal disorders in musicians report females at a higher risk for developing a MSI<sup>22</sup> and especially those who play string instruments or keyboard.<sup>20</sup> There is traditionally a high occurrence of MSI that occur at the neck and upper extremity: shoulders (32%), neck (28%), wrist/hands (11%), and thoracic spine (11%).<sup>22</sup> MSI within musicians has been attributed to additional risk factors such as: years of playing experience, type(s) of

instrument(s) played, hand dominance, body mass index, hours of playing, psychological stressors, and previous history of injury.<sup>23</sup>

Although there has been research on musicians playing in orchestras and concert settings, there are limited data on injury prevalence and injury risk factors associated with marching band musicians. Since 1887, marching musicians have been performing at football games and other local entertainment. Over time, this activity has become considerably more physically demanding.<sup>24</sup> In the United States alone, researchers have estimated approximately 27,000 individuals develop MSI each year while participating in marching band.<sup>1</sup> Participants in marching bands are at high risk of injury due to the complex physical activity and repetitive movements used during rehearsals.<sup>25</sup> Occurrence of overuse injuries has been noted in previous studies within the high school population<sup>26,27</sup> and at the collegiate level.<sup>1,28</sup> Collegiate injury rate estimates vary from 0.07 injuries per hour<sup>28</sup> to 124.03 injuries per 1,000 exposures.<sup>26</sup> However, all collegiate studies to date have utilized member self-completed forms for data collection. This limited amount of quality evidence – coupled with varied epidemiological metric use – causes comparison to traditional sport and dance athlete MSI to be challenging.

Drum and Bugle Corps is a specific type of marching art, commonly referred to as drum corps. It is considered substantially more demanding than traditional marching band. There is a scarce number of research studies performed in this setting and the literature available includes minimal retrospective, member self-reported data.<sup>29,30</sup> This method is not always the best form of data collection because it is prone to bias, among other disadvantages.<sup>29</sup> Drum corps has been around for nearly a half of a century and produces events for the world's most elite marching ensembles. The competitive touring season takes place during each summer in the United States, between the end of May and the beginning of August. There are approximately 150 participants

per World Class Drum Corps; each corps rehearses around ten hours per day, seven days a week, with nearly 30 performances over the course of two months.

Due to the physical demands this activity requires, and the extensive number of participation hours each member is exposed to, it is logical that the risk of MSI in drum corps would be significantly higher than in a traditional marching band. In addition to hours of exposure, there is a gender bias in a number of dance and musician studies showing females are most likely due sustain an injury.<sup>17,20</sup> However, it is unknown if this type of risk factor exists in the drum corps population based on current research. Based on similar performing arts genres like dance and orchestral musician literature, it could be reasonably inferred that females will incur more musculoskeletal injuries amongst drum corps members.

Some of the challenges in addressing injury rates in both sport and performing art are the lack of common definitions of injury and inconsistency in collecting exposure data.<sup>31-33</sup> While traditional sports teams have established a level of uniformity with incorporating injury surveillance programs, performing arts professionals such as ballet dancers and marching artists still lack standardization of surveillance programs. Although there are high physical demands across performing arts, research on the prevalence of MSI within these cohorts is still lacking. In 2007, Drum Corps International (DCI) established the Music Marching Health, Wellness & Safety Project to help medical practitioners across the community establish standards, safety regulations, and appropriate care for participants in marching music ensembles across the United States. This work is still in its infancy and additional research is needed.

Due to the physically challenging circumstances Drum and Bugle Corps require, it is of paramount importance to understand and recognize these performing artists as athletes and to collect data on the injuries that develop over the course of a season. Therefore, the purpose of

this study is to determine the season-specific injury prevalence and identify factors associated with musculoskeletal injuries in a conveniently selected sample of a single World Class Drum and Bugle Corps in the United States over the course of two seasons in order to increase the awareness of injury within this unique population.

## **METHODS**

### **Design & Setting**

This retrospective cross-sectional study used data collected on musculoskeletal injuries in a single World Class Drum and Bugle Corps. The data from May 2018 through August 2019 Drum Corps International competitive seasons were utilized. Data collection included subjects' demographic information, total years of DCI experience, previous experience in drum corps, and health history. The corps administrative staff securely transmitted this de-identified data to the research team. This study was reviewed and approved as exempt by the University's Institutional Review Board (IRB) to protect human subjects.

### **Participants**

Musculoskeletal injury data were collected on all members who participated in a single World Class Drum and Bugle Corps over the course of two seasons: 2018 and 2019. The World Class Drum and Bugle Corps is under the administration of Drum Corps International competition and competes across the United States over the summer tour season. The 2018 season included 152 members, and the 2019 season included 154 members. The members were divided into three separate captions: colorguard, brass, and percussion. Of those captions, individuals were divided into subsequent sections: brass; trumpet, baritone, mellophone, and tuba and percussion; snare drum, tenor drum, bass drum, and front ensemble. Exclusion criteria included any participants who were alternates (as these individuals did not have a permanent spot

on the roster and were not a contracted member), and drum majors. Individuals were also excluded if they could not communicate effectively in the English language.

## **Procedures**

The drum corps employed medical staff personnel over the course of the tour season. Prior to the start of the season, each member must have completed a physician-conducted pre-participation examination (PPE). In May of each year, individuals completed a demographic and health history form consisting of questions considering age, sex, height, weight, caption, section, and total years of DCI experience. The medical staff for this corps collected all the PPEs, demographic information, as well as the member's health history.

## **MSI Data**

Musculoskeletal injuries were recorded by the medical staff for the corps and extracted from the electronic medical record (EMR) source used for each specific season. All EMR records were created by the licensed, certified athletic trainers who were contracted as the corps medical staff. In 2018, this included one AT, whereas the 2019 season included two ATs. In 2019, the ATs established standard injury reporting guidelines prior to the season that would be followed by both practitioners. Only the first injury per member was recorded and subsequently placed the member into the injured category. Recorded data included: caption and section (brass [baritone, mellophone, trumpet, tuba], colorguard, percussion [snare drum, tenor drum, bass drum, cymbals]); diagnosis (sprain, strain, fracture, stress fracture/reaction, tendonopathy, joint dysfunction); body region (lower extremity, upper extremity, head/neck/spine); side (left, right, central, bilateral, N/A); and acuity (acute, overuse, chronic). Lower extremity consisted of hip, upper leg, knee, lower leg, ankle, foot. Upper extremity consisted of shoulder, upper arm, elbow,

forearm, wrist, hand. Head/neck/spine consisted of head, cervical spine, thoracic spine, lumbar spine, pelvis, abdomen.

### **Statistical Analysis**

Descriptive statistics were used to summarize the distribution (frequencies, prevalence/proportions), central tendency (mean, median) and variability (range, variance, standard deviation) of MSI reports by sex, caption, and section. Bivariate analyses (chi-square tests, Fisher's exact tests) were used to compare the prevalence of MSI by sex, caption, total years of DCI experience, and BMI.

Binary logistic regression was used to identify correlates of MSI among study participants while accounting for potential effect modification and confounding effects. Potential pairwise interactions between explanatory (independent variables) were explored to determine effect modifications. In the absence of such effects, potential confounding was examined and controlled for in our final models. Selection of covariates in our final analysis models were informed by existing literature and statistical significance of covariates in our bivariate analyses. Participants with missing variable information in the proposed logistic model were dropped from the analysis. Statistical significance was set at  $p < 0.05$  for all analyses and performed using the IBM Statistical Package for the Social Sciences, version 27.0 software (IBM Corporation, Armonk: NY).

## **RESULTS**

### **Demographic Characteristics**

Descriptive statistics, including demographic and prevalence data, were calculated for the 2018 and 2019 Drum Corps International seasons separately and are seen in **Table 1**. A total of 149 members were included for the 2018 season (age =  $19.3 \pm 1.5$  years; height =  $173.6 \pm 10.5$

cm; weight =  $73.4 \pm 13.9$  kg; BMI =  $24.4 \pm 4.5$  kg/m<sup>2</sup>; total years of DCI experience =  $2.0 \pm 1.1$  years), and a total of 149 members were included for the 2019 season (age =  $19.4 \pm 1.6$  years; height =  $174.3 \pm 9.5$  cm; weight =  $74.0 \pm 15.1$  kg; BMI =  $24.2 \pm 4.3$  kg/m<sup>2</sup>; total years of DCI experience =  $2.2 \pm 1.3$  years). Two participating individuals from each season were indicated as significant outliers (further detail contained in **Multiple Logistic Regression**). These four individuals were not included in analysis.

Forty percent (61/149) of individuals competed in both seasons. The corps was 35.6% (53/149) female and 64.4% (96/149) male in the 2018 season, and 38.3% (57/149) female and 61.7% (92/149) male in 2019.

### **Prevalence of Injury for Sex**

In the 2018 DCI season, 48 individuals were injured, generating an injury prevalence of 32.2% (48/149). Twenty-one females sustained an injury with a prevalence of 39.6% (21/53), whereas males had 27 individuals become injured with a prevalence of 28.1% (27/96).

During the 2019 season, 39 individuals were injured with prevalence of 26.2% (39/149). Nineteen females sustained an injury with a prevalence of 33.3% (19/57), whereas males had a prevalence of 21.7% (20/92).

### **Prevalence of Injury for Age**

In 2018, the mean age was  $19.3 \pm 1.5$  years, ranging from ages 15 to 22 years. Sixty-seven percent ( $n=101$ ) of the corps consisted of individuals who were between the ages of 15-19 years [22.1% ( $n=36$ ) were 19 years old; 22.8% ( $n=34$ ) were 18 years old; 12.8% ( $n=19$ ) were 17 years old, 7.4% ( $n=11$ ) were 16 years old; and 0.7% ( $n=1$ ) were 15 years old] and were considered adolescents. Thirty-two percent ( $n=48$ ) of the corps consisted of members who were above the age of 20 years old [0% were 22 year old, 22.2% ( $n=27$ ) were 21 years old, 13.4%

( $n=20$ ) were 20 years old] and were considered adults. The highest prevalence of injury was among the 15-year-old with 100% ( $n=1$ , 1 injured) followed by individuals who were 18 years old with a prevalence of 47.1% ( $n=34$ , injured 16), 19 year-olds with 36.1% ( $n=36$ , 13 injured), 17 year-olds with 26.3% ( $n=19$ , injured 5), 20 year-olds with 25.0%, 21 year old's with 22.2%, 16 year-olds with 18.2%, and 0% for 22 year-olds. The chi-squared test for independence revealed  $p = 0.23$ , noting no statistically significant differences between prevalence of injury across age.

In 2019, the mean age was  $19.4 \pm 1.6$  years, with a range of 15-22 years. Sixty-four percent ( $n=94$ ) of the corps consisted of individuals who were between the ages of 15-19 [26.8% ( $n=40$ ) were 19 years old, 12.1% ( $n=18$ ) were 18 years old, 18.1% ( $n=27$ ) were 17 years old, 4.7% ( $n=7$ ) were 16 years old, and 1.3% ( $n=2$ ) were 15 years old and were considered adolescents and 36% ( $n=55$ ) of the corps consisted of members who were above the age of 20 years old [18.1% ( $n=27$ ) were 20 years old, 17.4% ( $n=26$ ) were 21 years old, 1.3% ( $n=2$ ) were 22 years] and were considered adults. The highest prevalence of injury was among the 16-year-old individuals with 57.1% ( $n=7$ , 4 injured) followed by individuals who were 15 years old with prevalence 50% ( $n=2$ , 1 injured), 34.6% ( $n=26$ , 9 injured) for 21-year-old individuals, 33.3% ( $n=18$ , injured 6) for the 18 years old, 22.2% ( $n=27$ , 6 injured) for 17-year-olds as well as 20 years old, 17.5% ( $n=40$ , 7 injured) for 19-year-olds, and 0% for 22 year-olds. The chi-squared test for independence revealed  $p = 0.32$ , noting no statistically significant differences between prevalence of injury across age.

### **Prevalence of Injury for BMI**



In 2018, obese individuals had the highest prevalence of injury 52.6% ( $n=19$ , 10 injured) followed by overweight individuals with prevalence 41.9% ( $n=31$ , injured 13), healthy weight 25.8% ( $n=93$ , 24 injured) and underweight 16.7% ( $n=6$ , 1 injured) (BMI  $p=0.06$ ).

Again in 2019, obese individuals had the highest prevalence of injury 33.3% ( $n=15$ , 5 injured), followed by healthy individuals with prevalence 26.5% ( $n=102$ , 27 injured), 24.1% ( $n=29$ , 7 injured) for overweight individuals, and 0.0% for underweight individuals. The chi-squared test for independence revealed  $p = 0.68$ , noting no statistically significant differences between prevalence of injury across BMI categories.

### **Prevalence of Injury for Caption/Section**

#### Brass

In 2018, there were a total of 72 brass members representing 48.3% of the corps. The prevalence of injury in brass members was 30.6% (22/72). Injury prevalence for brass sections were as follows: baritones 20.8% (5/24), mellophone 33.3% (4/12), trumpet 25% (6/24), and tuba 58.3% (7/12) ( $p = 0.06$ ).

In 2019, there were a total of 79 brass members representing 53% of the corps. The prevalence of injury in brass members was 26.6% (21/79). Injury prevalence for brass sections were as follows: baritones 26.1% (6/23), mellophone 25% (5/20), trumpet 25% (6/24), and tuba 33.3% (4/12).

#### Colorguard

In 2018, there were a total of 42 colorguard members representing 28.2% of the corps. Nineteen individuals sustained an injury, producing a prevalence of 45.2% (19/42). In 2019, there were a total of 38 colorguard members representing 25.5% of the corps. Fourteen individuals sustained an injury, producing a prevalence of 36.8% (14/38).

## Percussion

In 2018, there were a total of 35 percussion members representing 23.5% of the corps. The prevalence of injury in percussion members was 23.5% (7/35). Injury prevalence for sections were as follows: snare 25% (2/8), tenor and bass drum 0%, cymbals 25% (1/4) and front ensemble 26.7% (4/15).

In 2019, there were a total of 32 percussion members representing 21.5% of the corps. The prevalence of injury in percussion members was 12.5% (4/32). Injury prevalence for sections were as follows: snare 14.3% (1/7), tenor 50% (2/4), bass drum and cymbals 0%, and front ensemble 8.3% (1/12).

## **Prevalence of Injury for Total Years of Drum Corps International Experience**

In 2018, the mean total years of DCI experience across the corps was  $2.02 \pm 1.15$  years. Brass caption members had the highest average experience ( $2.14 \pm 1.13$  years), whereas percussion caption members had the lowest average experience ( $1.86 \pm 1.22$  years).

We further categorized this variable into 1-year, 2-year, 3-year, 4-year, 5-year, and 6-years of experience. In 2018, 1-year individuals made up 39.6% (59/149) of the corps and 2-year individuals made up 36.9% (55/149) of the corps with 3-years with 12.1% (18/149), 4-year 4.7% (7/149), 5-years 6.7% (10/149), and 6-years 0.0% (0/149). First-year individuals had the highest injury prevalence at 44.1% (26/59), 3-year individuals falling next at 33.3% (6/18), and 2-year individuals third at 27.3% (15/55). Chi-square analysis revealed statistical significance for total years of DCI experience in 2018 ( $p = 0.04$ ).

In 2019, the mean total years of DCI experience across the corps was  $2.02 \pm 1.15$  years. Colorguard caption members had the highest average experience ( $2.39 \pm 1.26$  years), whereas percussion caption members had the lowest average experience ( $1.94 \pm 1.16$  years). One-year

individuals made up 37.6% (56/149) of the corps; 2-year individuals 34.2% (51/149); 3-year individuals 11.4% (17/149); 4-year individuals 8.1% (12/149); 5-year individuals 8.1% (12/149); and 6-year individuals 0.7% (1/149). While injury prevalence was still highest in first-year individuals at 30.4% (17/56), prevalence across the remaining experience categories was more consistent in this season (2-years = 23.5% [12/51]; 3-years = 23.5% [4/17]; 4-years = 25.0% [3/12]; 5-years = 25.0% [3/12]; 6-years = 0.0% [0/1]). Chi-square analysis revealed no statistically significant difference ( $p=0.95$ ).

Further details for total years of experience in DCI can be found in **Table 1**.

### Diagnosis

Frequency and prevalence of injuries based on sex, caption, section, diagnosis, body region (lower extremity, torso, upper extremity), and acuity are denoted in **Tables 2 and 3**.

In 2018, strains were found to have the highest prevalence of injury with 16.8% (25/149), sprains and tendinopathy were both second highest with 6.7% (10/149) followed by joint dysfunction with 2.0% (3/149), and finally fasciitis with 0.0% (0/149).

In 2019, strains were also found to have the highest prevalence of injury with 12.8% (19/149), sprains were second highest with 7.4% (11/149), tendinopathy with 4.7% (7/149), followed by joint dysfunction and fasciitis each with 0.7% (1/149) respectively.

### Body Region

In 2018, lower extremity injury had the highest prevalence of 15.4% (24/149), followed by Back/Spine/Head with 12.0% (18/149), and upper extremity 4.7% (7/149). In 2019, lower extremity was again the highest prevalence 20.8% (31/149), followed by upper extremity 3.4% (5/149), and Back/Spine/Head 1.3% (2/149).

### Acuity

In 2018, acute injuries had the highest prevalence with 15.4% (23/149) with overuse being a close second with 14%.8 (22/149), and chronic with 2.0% (3/149). In 2019, acute injuries again were the highest with a prevalence of 20.1% (30/149), overuse 4.7% (7/149), and chronic with 1.3% (2/149).

### **Multiple Logistic Regression**

A binomial logistic regression was performed for each season independently to determine the effects of age, sex, BMI category, caption, and total years of DCI experience on the likelihood that members were injured. Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell<sup>34</sup> procedure. A Bonferroni correction was applied using all seven terms in the model resulting in statistical significance being accepted when  $p < 0.0071$ .<sup>35</sup>

For 2018, based on this analysis, all continuous independent variables (age, total years of DCI experience) were found to be linearly related to the logit of the dependent variable. There were two studentized residuals with values of 2.513 and 2.646 standard deviations, which were removed from analysis. The logistic regression model was statistically significant,  $\chi^2(8) = 25.335$ ,  $p = 0.001$ . The model explained 21.9% (Nagelkerke  $R^2$ ) of the variance in injury occurrence and correctly classified 69.8% of cases. Sensitivity was 54.8%, specificity was 73.7%, positive predictive value was 35.4%, and negative predictive value was 86.1%. Of the five predictor variables, only two were statistically significant: BMI, overweight and obese; and total years of DCI experience (see **Table 4**). Overweight members – as defined by the Center of Disease Control BMI calculator for child and teen for individuals between the ages of 16-19 and adults BMI calculator for individuals over the age of 19 – were 2.08 times more likely to be injured and obese members were 3.19 times more likely to be injured compared to their

underweight counterparts. With each 1-year decrease in a member's total years of DCI experience, their likelihood of being injured increased by 2.

For 2019, all continuous independent variables (age, total years of DCI experience) were found to be linearly related to the logit of the dependent variable. There were two studentized residuals with values of 2.521 and 2.823 standard deviations, which were removed from analysis. The logistic regression model was not statistically significant,  $\chi^2(8) = 8.325, p = 0.402$ . The model explained 8.0% (Nagelkerke  $R^2$ ) of the variance in injury occurrence and correctly classified 73.8% of cases. Sensitivity was 0.0%, specificity was 73.8%, positive predictive value was 0.0%, and negative predictive value was 100.0%. Of the five predictor variables, none were statistically significant for the 2019 season (as shown in **Table 5**). In addition to not meeting statistical significance for this year, the two variables which demonstrated statistical significance in the 2018 model demonstrated odds ratios of 0.000 (BMI, underweight) and 0.902 (total years of DCI experience). However, for 2019, percussion did demonstrate an increased likelihood of injury amongst the percussion and the colorguard when compared to the brass caption, at 4.075 and 3.067 respectively.

### **Crude Odds Ratios and Adjusted Odds Ratios**

Crude Odds Ratios (OR), Adjusted Odds Ratios (Adjusted OR), and 95% Confidence Intervals (CI) for 2018 and 2019 for demographic variables of interest are denoted in **Table 6**

Sex

Females were found to be 1.607 times more likely to sustain an injury when compared to males in 2018 (OR = 1.60795, CI 0.798 to 3.234). Likewise, 2019 data reported females to have an OR of 1.900 (95% CI 0.869 to 4.615) showing that they have almost double the probability of developing an injury during the season. When adjusting for our potential confounders (sex, age,

BMI, caption, and total years of DCI experience) we see 2018 and 2019's adjusted ORs increase (2018: Adjusted OR = 1.804, CI 0.804 to 4.050; 2019: Adjusted OR = 2.002, CI 0.869 to 4.615) respectively showing the confounders to present a probable association when looking at sex.

### Age

The crude and adjusted odds ratios for age were relatively similar between seasons. Both years indicated that the older individuals were, the less likely they were to sustain an injury (2018: crude OR = 0.891 [95% CI 0.709 to 1.119]; adjusted OR = 0.851, [95% CI 0.654 to 1.107]) (2019: crude OR = 0.910 [95% CI 0.719 to 1.151]; adjusted OR = 0.985 [95% CI 0.761 to 1.274]).

### BMI Categories

Four categories were used for BMI: underweight, healthy/normal weight, overweight, and obese. Based-on demographic information provided on members' preparticipation health histories, we calculated BMI and then categorized each result into one of four groups. These four BMI groups were assigned based on the Center of Disease Control BMI calculator for child and teen for individuals between the ages of 16-19. The BMI calculation for the group of individuals older than the age of 19 were calculated based on the Center of Disease Controls adult BMI calculator.

Healthy/Normal weight was used as the reference category, based-on previous literature supporting the standing of this category as least likely to experience MSI. When comparing healthy weight to underweight individuals' crude OR for each season independently, a lower probability of underweight individuals to sustain an injury is seen (2018: 0.575 [95% CI 0.064 to 5.173]; and 2019: 0.392 [95% CI 0.020 to 7.840]). When adjusting for potential confounding, the

adjusted OR for 2018 decreased to 0.298 (95% CI 0.100 to 0.893), and 2019 to 0.804 (95% CI 0.247 to 2.618).

When analyzing crude ORs for overweight and obese individuals across both seasons, we see a higher likelihood of injury – except for 2019 overweight individuals (OR = 0.884 [95% CI = 0.339 to 2.302]). These variables demonstrate consistently high crude ORs when compared across all the variables included in analysis. However, the respective adjusted ORs for each of these measures establishes a considerable effect of confounding. All adjusted ORs invert to measures below 1.00, indicating a protective effect versus the positive effect indicated by the crude ORs. See **Table 6** for specific measures.

#### Caption

Complete ORs for injury based-on caption are addressed in **Table 6**. Brass was used as the reference category. In both 2018 and 2019, the colorguard caption demonstrated positive crude and adjusted ORs, indicating higher likelihood of injury in comparison to the brass caption (2018: Crude = 1.878 [95% CI: 0.854 to 4.128]; Adjusted = 2.196 [95% CI: 0.753 to 6.408]) (2019: Crude = 1.611 [95% CI: 0.705 to 3.693]; Adjusted = 2.386 [95% CI: 0.715 to 7.960]). The percussion caption demonstrated crude ORs in 2018 (0.568 [95% CI: 0.216 to 1.496]) and 2019 (0.395 [95% CI: 0.124 to 1.259]) both indicating a decreased likelihood of injury. However, adjusted ORs show an effect of confounding at 2.928 (95% CI: 0.867 to 9.889) and 3.351 (95% CI: 0.788 to 14.252) for the 2018 and 2019 seasons respectively.

#### Total Years of Drum Corps International Experience

When analyzing 2018 and 2019 seasons individually, similarities are seen across both years. For every year participated in DCI, the odds of sustaining an injury decreased. In 2018, the more experience an individual had, the less likely they were to sustain an injury. In 2018, the

crude ORs showed injury occurrence to decrease by approximately half as experience increases (OR = 0.573 [95% CI: 0.387 to 0.849]) and even less likelihood when adjusting for potential confounders (Adjusted OR = 0.554 [95% CI: 0.366 to 0.839]). Similarly, the 2019 season showed no association of injury with more DCI experience (OR = 0.940 [95% CI: 0.671 to 1.218]; adjusted OR = 0.875 [95% CI: 0.635 to 1.205]).

## **DISCUSSION**

The purpose of this study was to determine the prevalence of musculoskeletal injury in a World Class Drum and Bugle Corps over the course of two seasons. We additionally sought to identify factors associated with injury occurrence in this unique population of performing artists. To our knowledge, this study is the first to analyze the prevalence and correlates of musculoskeletal injury in drum corps. Primary findings from this study included higher BMI and fewer years of DCI experience were associated with higher odds of MSI in the 2018 season. However, these factors were not associated with MSI in 2019 season. Despite a growing number of young performers participating in the activity, healthcare and wellness provisions have lacked across corps when compared to similar physically demanding activities. Identifying MSI prevalence and injury correlates may support the need for additional healthcare provisions.

### **Overall Prevalence**

The overall MSI prevalence amongst the 2018 corps members was 32.2% and 26.2% amongst the 2019 corps members. These results are similar to other studies that have investigated marching artists. Beckett et al.<sup>1</sup> demonstrated an injury prevalence of 25.0% among collegiate marching band members determined via a widely distributed online survey. Less closely related, a prevalence of 44-53% was found in United States Army Band members.<sup>1</sup> A higher prevalence of MSI in drum corps versus collegiate or high school marching band was



initially hypothesized due to the greater physical demands and exposure seen within drum corps.<sup>36</sup> However, it may be that due to the competitive audition process, drum corps are not admitting those into their ranks who might be predisposed to MSI. These individuals might otherwise be allowed to participate in high school or collegiate bands, however.

In addition to this self-selection process for drum corps members based-on the physical demands, exposure is also of significant interest for future studies. McPherson et al.<sup>36</sup> recorded an average drum corps member exposure of  $7.8 \pm 3.2$  hours/day when investigating injury occurrence in a single corps. This amounted to an injury incidence of 0.66 injuries per 1,000 member-exposure hours. The authors based this member-exposure hour measure on existing sports injury literature, meaning these measures should be comparable between similar epidemiological studies. As MSI prevalence has yet to be established in this population, we did not analyze data regarding exposure. If our drum corps sample's exposure is similar to McPherson et al.'s findings however – despite a relatively high MSI prevalence – we should see a contrastingly low MSI incidence. The drum corps community may therefore benefit to consider establishing exposure limits or guidelines for corps to utilize. These could be constructed and used similarly to the NCAA “20-hour rule,” or any other exposure eligibility rules.

## **Sex**

Existing literature on athletes and military personnel<sup>37</sup> report sex has a crucial influence in determining the individuals risk of injury.<sup>38</sup> Sex differences also exist in the presentation of MSI. Recognition of the differences between the burden of MSI in men and the burden of MSI in women – as well as their unique responses to treatment – is critical to optimizing orthopedic and sports medicine care. In this study, females were found to have a higher prevalence of injury when compared to their male counterparts. Even when adjusted for potential confounding,

females had a 1.47- and 1.29-times increased likelihood of being injured in 2018 and 2019, respectively.

This is a trend seen across many other traditional sports populations as well, with females encountering sports injuries more frequently than males when a difference is found.<sup>39,40</sup> In a recent epidemiological dance-related injuries study,<sup>41</sup> female dancers were four times more likely to sustain an injury than males. Previous studies have shown that women utilize medical care services more than men, potentially due to the differences in health perceptions and reporting of injury as women tend to seek help for prevention and illness compared to men.<sup>42</sup>

When assessing for injury risk, literature reports difficulty determining why female are more predisposed and continue to experience more injuries compared to their male counterparts. Much like dance literature, there is a lack of consensus regarding risk factors for all types of injured female performers. This may be due to the lack of standard injury definition, available medical staff, time loss considerations, and quality research studies.<sup>16,43,44</sup> Research must continue to improve our understanding of patient differences and the role these differences play in moderating each patient's experience with, and treatment outcomes for, varied musculoskeletal injuries. Developing research that investigate sex-specific hypothesis could lead to the development of evidence-based, sex-specific treatment algorithms for a variety of sports injuries, and, in turn, better musculoskeletal care for all athletes.

## **Age**

The literature also suggests age to be a potential contributor to injury prevalence, with younger individuals more likely to sustain injury.<sup>45</sup> Additionally, in sports injury literature, the adolescent growth spurt is widely linked to increased injury risk due to increased muscle-tendon tightness and reduced physical strength in the sports injury literature.<sup>45,46</sup> Our subjects' ages

ranged from  $19.3 \pm 1.5$  years (2018) to  $19.4 \pm 1.6$  years (2019). This categorizes the group into a mix of adolescent and adult individuals.

Among adolescent physical activity-related injuries in sports clubs, injury prevalence has been reported as 47% in one study.<sup>47</sup> Despite a higher prevalence than our current sample, this study also reported the older individuals were less likely to sustain an injury than their younger counterparts (OR = 0.63 [95% CI: 0.53-0.75]).<sup>48</sup> This comparison shows similar findings to our study where across the 2018 season, less experienced individuals encountered higher injury prevalence: 2018; 1 year of DCI experience 44.1%, 2 years 27.3%, 3 years 33.3%, 4 years 14.3% 5+ years 0.0%. However, 2019 showed relatively no association. This is potentially due to the 40% of members who participated in both seasons. Theoretically, this trend could be explained by a training or familiarization effect, in which more experienced members are able to cope with the physical demands better than those who have never been exposed to them. However, ultimately, a larger sample size and additional corps reporting could help reveal more definitive conclusions regarding age's impact on MSI occurrence in drum corps.

## **BMI**

Previous literature on prevalence of injury in marching band<sup>1</sup>, traditional sports epidemiological studies<sup>49</sup>, and military personnel<sup>50</sup> report BMI to be a risk factor for sustaining a MSI. An increase in injury prevalence can be attributed to higher body fat percentage therefore increasing the load that can impose additional stress on connective tissue causing risk of MSI. Many studies examined BMI as a risk factor for all types of injuries, but lacks identifying specific injury types.<sup>50</sup> Particular injuries may not be related to a single risk factor, but instead are the result of an interaction among several or many risk factors.

Dos Santos Bunn et al.'s<sup>50</sup> systematic review with meta-analysis on military personnel and musculoskeletal injuries reported overweight or obese individuals to have a 16% increased risk of injury compared to those who were categorized as normal/healthy or underweight. With sports injuries and adolescents, a higher BMI has been shown to increase risk for all sports injuries compared to healthy weight.<sup>49</sup> Other studies examining sociodemographic risk factors for sports injuries in adolescents concluded with weekly exposure and BMI to simultaneously predict sports injuries. Becket et al.<sup>1</sup> reported higher BMI as a direct cause of injury in colorguard and collegiate marching band participants. These findings parallel our study's results, where adolescent overweight/obese individuals in the drum corps had higher prevalence of injury (2018: overweight prevalence = 41.9%, obese prevalence = 52.6%; 2019: obese prevalence = 33.3%.) Crude OR's showed overweight individuals to be two times and obese individuals to be three times more likely to sustain an injury in 2018 (Overweight Crude OR 2.076 [95% CI 0.886 to 4.864]; Obese Crude OR 3.194 [95% CI 1.160 to 8.800])

### **Caption**

While we hypothesized that a member's caption would significantly influence their likelihood of sustaining a MSI, our results were not as clear regarding the impact of this consideration. Within the logistic regression models, caption did not meet statistical significance for inclusion. Additionally, the chi-squared tests for each year produced  $p$ -values of  $p = 0.06$  and  $p = 0.07$ .

Our hypothesis of the colorguard caption having the highest MSI prevalence, however, was confirmed at 45.2% (2018) and 36.8% (2019). With the brass caption encountering the next highest MSI prevalence at 30.6% and 26.6%, this difference is clinically impactful. In 2018, the

colorguard section had nearly half the members of the brass section, but comparable numbers of injured members.

Colorguard members are known to perform more gross movement than any other members in the corps. It is also clear when working with drum corps that the colorguard members typically encounter higher levels of physical activity exposure. This is as the other two captions – brass and percussion – will typically have one of the four standard rehearsals per day to work with most focus on music. As the colorguard is always physically moving to some extent while performing, this rehearsal (which would be seen as more of a physical rest period for other sections) is not necessarily any less demanding.

While there currently exists no literature on the topic, anecdotally among drum corps medical providers and instructors it is also known that there is a particular sociocultural-style stigma surrounding the percussion caption reporting injury and/or pain. This may be related in some part to the increased difficulty in replacing a percussion member during the season – for whatever reason – when compared to a brass or colorguard member. While our current study did not evaluate injury severity, it would be interesting in future investigations to see if the related severity of injuries amongst the percussion section is also lower in addition to the lower MSI prevalence.

### **Total years of Drum Corps Experience**

The results of this study regarding prior experience of drum corps members are perhaps the most perplexing. For the 2018 season, chi-square analysis met statistical significance at  $p = 0.04$  regarding total years of DCI experience and MSI occurrence, but for 2019  $p = 0.96$ . Additionally, the logistic regression indicated adjusted ORs of 0.554 and 0.947 respectively. Such large differences in the year-to-year influence of prior experience on MSI occurrence

suggests that our data sets were quite variable between years. While the logistic regression analysis indicated total years of drum corps experience to be statistically significant for inclusion in the 2018 model ( $p = 0.003$ ), we are cautious to make definitive conclusions based-on this variability (2019 model,  $p = 0.529$ ). In particular, this area of investigation likely warrants further data collection and analysis.

### **Diagnosis, Body Region, and Acuity**

Diagnosis, body region, and acuity of injury varied across both seasons. Both seasons reported the diagnosis with the highest prevalence of injury were individuals who developed strains (2018:  $n = 25$  [16.3%]; 2019:  $n = 19$  [12.4%]) with follow up to sprains with being second highest prevalence (2018:  $n = 10$  [6.5%]; 2019:  $n = 11$  [7.2%]) with tendinopathy in 2018 also ranking second highest ( $n = 10$  [6.5%]). The Center of Disease Control and Prevention (CDC) has estimated 4.3 million nonfatal sports and recreational related injuries, similar to nontraditional activities such as drum corps, to occur in the United States annually.<sup>5</sup> The most common injury diagnosis in emergency departments are strains/sprains (29.1% [95% CI: 25.2% to 33.0%]) much like the results found in this study.

Much like similar marching arts,<sup>26,27,51</sup> military,<sup>4,52,53</sup> and dance populations,<sup>54</sup> the most frequent body region to sustain injury was the lower extremity (2018: 16.3%; 2019: 20.3%) as compared to other categories such as back/spine/head and upper extremity. While unsurprising, it is important for clinicians to note that certain sections still encountered significant upper extremity injuries, such as colorguard and percussion. Both require fine manipulation of a variety of implements through the hands, with colorguard also demanding gross motor movements of the elbows and shoulders. All these movements are of a repetitious nature.

It is because of this repetitious nature of activities in drum corps – and most performing arts – that our team was surprised to find acute injuries occurred more frequently across the data in both seasons. The 2019 season demonstrated this to a higher degree than the 2018 season, with 77% and 48% of all injuries being acute, respectively. Further study is needed to elucidate the true reasons for this, but hypotheses may include chronic and overuse injuries being seen more as expected and therefore not benefiting from reporting to the corps clinician.

### **Clinical Implications**

Ultimately, many of the injury determinants for drum corps activity are likely more influenced by other environmental factors not reviewed in this study. While our analyses demonstrated the trends, differences, and statistical significance reviewed specifically in the above sections, we see considerable variance between the two data sets. From a theoretical basis, it makes clear sense that one of the largest determinants of MSI in drum corps would be the nature of each season's show design – the choreography and movements that are demanded of the members each year.

Unlike traditional sports, where the movement vocabulary is generally maintained throughout the athlete's entire career, drum corps members are increasingly asked to perform drastically different movements from year-to-year. This can be compared to dancers experiencing world premieres every season, having no consistent repertoire. Per our 2018 and 2019 seasons, the show may have been drastically different, potentially giving light to the differing significance between the two years MSI results. Because of this, while BMI, total years of DCI experience, caption, and other variables investigated in this study may assist somewhat in determining a member's likelihood of injury, these variables may be expected to have little use

in comparison to environmental components of choreography, pre-season conditioning, sleeping habits, field conditions, and other related considerations.

## **Limitations**

There are inherent flaws and limitations to using a retrospective cross-sectional study design. This was a conveniently sampled group from which we collected data via retrospective chart review. While we were able to collect and analyze data from two seasons, additional review for the 2020 season was initially planned. However, due to the global coronavirus pandemic (SARS-CoV-2), this collection was not able to be conducted.

While our study utilized clinician documented MSI data, this still required a member to report injury to the clinician. Anecdotally, many marching band members (and more specifically to this study, drum corps members) have never had to report to a healthcare provider for injuries. Secondly, individuals may not report injury due to the likelihood of being sent home if their injury causes them to be removed from rehearsal or performance. Both scenarios could mask the true prevalence of injury.

In the 2019 season, there were two healthcare providers diagnosing injuries which could have caused a potential of misclassification or discrepancy in injury diagnosis. Analysis of a singular corps makes this data difficult to generalize across all drum corps individuals. Including other corps could help make this data more diverse across DCI and increase the sampled population. Another limitation of the study was only collecting data for two seasons.

We did not carry out a sensitivity analysis because we looked at a complete case analysis due to having a complete case group (i.e., no missing data). There was limited control over the differing exposure levels between captions, as well as choreography intensity and difficulty between both seasons potentially skewing injury prevalence. Future research should address



previous injury as a risk factor as many epidemiology studies attribute this as a common risk factor. Lastly, membership rosters are not consistent from year-to-year potentially causing new member rates to increase and difficulty following and comparing individuals across seasons.

### **Future Directions**

In recent years, the presence of a medical professional, often an athletic trainer, has become more common in drum corps. As this staffing model becomes a precedent, the opportunity to study injuries in the activity becomes more feasible. As was seen with this study, injury data from even one season within a single drum corps provided invaluable information to the corps, healthcare professionals working with corps, and prospective drum corps healthcare professionals. An effort should be made to continue to grow this body of knowledge, bringing in information from more than just a single drum corps. More rigorous methods should be used to collect demographic information, a larger population such as multiple drum corps should be monitored, and members should be tracked as they participate each following year.

Marching arts medicine research has begun to reach a stage where prospective, longitudinal, multi-site studies are the reasonable next step. We hope that further analysis of specific colorguard positions (e.g., rifle, flag) will be explored to further understand the differing injuries amongst the cohort, if any at all.

Reporting accurate exposure has been shown to be both challenging and limited within the drum corps population,<sup>36</sup> but has been achieved within the collegiate sphere.<sup>26</sup> Perhaps a best next step would be to ascertain burden on the way to discerning exposure levels.

Codifying metrics to assess and report on the environmental conditions discussed will also be critical as injury prediction and prevention efforts proceed in these cohorts.

## **CONCLUSION**

This research study provides one of the first data sets exploring musculoskeletal injuries and demographics in a World Class Drum and Bugle Corps over the course of two seasons. It allows this population recognition for its challenging and demanding efforts regarding injury prevalence. This data demonstrates the continued need for focused efforts on studying this population over the course of multiple seasons as injury prevalence is associated in both seasons.

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## TABLES AND FIGURES

**Error! Reference source not found.** **Table 1:** Demographic and prevalence data for all members.

	2018			<i>p</i>	2019			<i>p</i>
	Frequency <i>n</i> (%)	Injured/ Uninjured	Prevalence		Frequency <i>n</i> (%)	Injured/ Uninjured	Prevalence	
<b>Overall</b>	<b>149</b>	<b>48/101</b>	<b>32.2</b>		<b>149</b>	<b>39/110</b>	<b>26.2</b>	
<b>Sex</b>				<b>0.15</b>				<b>0.12</b>
Females	53 (35.6)	21/32	39.6		57 (38.3)	19/38	33.3	
Males	96 (64.4)	27/69	28.1		92 (61.7)	20/72	21.7	
<b>Age (Years)</b>				<b>0.23</b>				<b>0.32</b>
15	1 (0.7)	1/0	100.0		2 (1.3)	1/1	50.0	
16	11 (7.4)	2/9	18.2		7 (4.7)	4/3	57.1	
17	19 (12.8)	5/14	26.3		27 (18.1)	6/21	22.2	
18	34 (22.8)	16/18	47.1		18 (12.1)	6/12	33.3	
19	36 (22.1)	13/23	36.1		40 (26.8)	7/33	17.5	
20	20 (13.4)	5/15	25.0		27 (18.1)	6/21	22.2	
21	27 (18.1)	6/21	22.2		26 (17.4)	9/17	34.6	
22	1 (0.7)	0/1	0.0		2 (1.3)	0/2	0.0	
<b>BMI</b>				<b>0.06</b>				<b>0.68</b>
Underweight*	6 (4.0)	1/5	16.7		3 (2.0)	0/3	0.0	
Healthy weight†	93 (62.4)	24/69	25.8		102 (68.5)	27/75	26.5	
Overweight‡	31 (20.8)	13/18	41.9		29 (19.5)	7/22	24.1	
Obese§	19 (12.8)	10/9	52.6		15 (10.1)	5/10	33.3	
<b>Caption</b>				<b>0.06</b>				<b>0.07</b>
<i>Brass</i>	72 (48.3)	22/50	30.6		79 (53.0)	21/58	26.6	
Baritone	24 (16.1)	5/19	20.8		23 (15.4)	6/17	26.1	
Mellophone	12 (8.1)	4/8	33.3		20 (13.4)	5/15	25.0	
Trumpet	24 (16.1)	6/18	25.0		24 (16.1)	6/18	25.0	
Tuba	12 (8.1)	7/5	58.3		12 (8.1)	4/8	33.3	
<i>Colorguard</i>	42 (28.2)	19/23	45.2		38 (25.5)	14/24	36.8	
<i>Percussion</i>	35 (23.5)	7/28	20.0		32 (21.5)	4/28	12.5	
Snare	8 (5.4)	2/6	25.0		7 (4.7)	1/6	14.3	
Tenor Drum	4 (2.7)	0/4	0.0		4 (2.7)	2/2	50.0	
Bass Drum	4 (2.7)	0/4	0.0		5 (3.4)	0/5	0.0	
Cymbals	4 (2.7)	1/3	25.0		4 (2.7)	0/4	0.0	
Front Ens.	15 (10.1)	4/11	26.7		12 (8.1)	1/11	8.3	
<b>Total Years of DCI Experience</b>				<b>0.04</b>				<b>0.95</b>
1	59 (39.6)	26/33	44.1		56 (37.6)	17/39	30.4	
2	55 (36.9)	15/40	27.3		51 (34.2)	12/39	23.5	
3	18 (12.1)	6/12	33.3		17 (11.4)	4/13	23.5	
4	7 (4.7)	1/6	14.3		12 (8.1)	3/9	25.0	

5	10 (6.7)	0/10	0.0	12 (8.1)	3/9	25.0
6	0 (0.0)	0 (0.0)	0.0	1 (0.7)	0/1	0.0

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\*Underweight = Less than 5<sup>th</sup> percentile according to CDC Guidelines for Child and Teen BMI Categories

†Normal or Healthy Weight = 5<sup>th</sup> percentile to less than 85<sup>th</sup> percentile according to CDC Guidelines for Child and Teen BMI Categories

‡Overweight = 85<sup>th</sup> to less than the 95<sup>th</sup> percentile according to CDC Guidelines for Child and Teen BMI Categories

§Obese = 95<sup>th</sup> percentile or greater according to CDC Guidelines for Child and Teen BMI Categories

**Table 2:** Frequency and prevalence of injuries according to diagnosis, body region, and acuity.

	<b>2018</b>		<b>2019</b>	
	<b>(N of injuries = 48)</b> <b>(N of members = 149)</b>		<b>(N of injuries = 39)</b> <b>(N of members = 149)</b>	
	Frequency	Prevalence (%)	Frequency	Prevalence (%)
<b>Diagnosis</b>				
Sprain	10	6.7	11	7.4
Strain	25	16.8	19	12.8
Tendinopathy	10	6.7	7	4.7
Fasciitis	0	0	1	0.7
Joint Dysfunction	3	2.0	1	0.7
<b>Lower Extremity</b>	<b>23</b>	<b>15.4</b>	<b>31</b>	<b>20.8</b>
Foot/Ankle	9	6.0	11	7.4
Lower Leg	10	6.7	4	2.7
Knee/Thigh	11	7.4	9	6.0
Hip	8	5.4	8	5.4
<b>Back / Spine / Head</b>	<b>18</b>	<b>12.0</b>	<b>2</b>	<b>1.3</b>
<b>Upper Extremity</b>	<b>7</b>	<b>4.7</b>	<b>5</b>	<b>3.4</b>
<b>Acuity</b>				
Acute	23	15.4	30	20.1
Chronic	3	2.0	2	1.3
Overuse	22	14.8	7	4.7

**Error! Reference source not found.:** Frequency and prevalence (%) of injuries based on sex, caption, section, and body region.

	<b>2018</b> (N of injuries = 48) (N of members = 149)						<b>2019</b> (N of injuries = 39) (N of members = 149)					
	Foot / Ankle	Lower Leg	Knee / Thigh	Hip	Spine	Upper Ext	Foot / Ankle	Lower Leg	Knee / Thigh	Hip	Spine	Upper Ext.
<b>Sex</b>												
Female	2 (3.8)	5 (9.4)	5 (9.4)	3 (5.7)	3 (5.7)	3 (5.7)	6 (10.5)	2 (3.5)	3 (5.3)	3 (5.3)	1 (1.8)	4 (7.0)
Males	7 (7.3)	5 (5.2)	6 (6.3)	5 (5.2)	3 (3.1)	1 (1.0)	5 (5.4)	2 (2.2)	6 (6.5)	5 (5.4)	1 (1.1)	1 (1.1)
<b>Caption</b>												
Brass	7 (9.7)	6 (8.3)	4 (4.9)	3 (4.2)	2 (2.8)	0 (0.0)	5 (6.3)	2 (2.5)	6 (7.6)	5 (6.3)	1 (1.3)	2 (2.5)
Colorguard	1 (2.4)	3 (7.1)	4 (9.5)	5 (11.9)	3 (7.1)	3 (7.1)	4 (10.5)	2 (5.3)	3 (7.9)	2 (5.3)	1 (2.6)	2 (5.3)
Percussion	1 (2.9)	1 (2.9)	3 (8.6)	0 (0.0)	1 (2.9)	1 (2.9)	2 (6.3)	0 (0.0)	0 (0.0)	1 (3.1)	0 (0.0)	1 (3.1)
<b>Section</b>												
Baritone	0 (0.0)	2 (8.3)	2 (8.3)	0 (0.0)	1 (4.2)	0 (0.0)	2 (8.7)	0 (0.0)	3 (13.0)	1 (4.3)	0 (0.0)	0 (0.0)
Mellophone	3 (25.0)	1 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.0)	1 (5.0)	1 (5.0)	0 (0.0)	2 (10.0)
Trumpet	0 (0.0)	3 (12.5)	1 (4.2)	2 (8.3)	0 (0.0)	0 (0.0)	2 (8.3)	1 (4.2)	1 (4.2)	1 (4.2)	1 (4.2)	0 (0.0)
Tuba	4 (33.3)	0 (0.0)	1 (8.3)	1 (8.3)	1 (8.3)	0 (0.0)	1 (8.3)	0 (0.0)	1 (8.3)	2 (16.7)	0 (0.0)	0 (0.0)
Snare Drum	0 (0.0)	1 (12.5)	0 (0.0)	0 (0.0)	1 (12.5)	0 (0.0)	1 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Tenor Drum	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)
Bass Drum	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Cymbals	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Front Ens.	1 (6.7)	0 (0.0)	3 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (8.3)

**Table 4:** Logistic regression predicting likelihood of injury based on age, sex, BMI category, caption, and total years of DCI experience for the 2018 season.

	<i>B</i>	SE	Wald	<i>df</i>	<i>p</i>	Adjusted Odds Ratio	95% CI for Odds Ratio	
							Lower	Upper
<b>Age</b>	-.162	.134	1.451	1	.228	.851	.654	1.107
<b>Sex</b>	-.388	.475	.669	1	.413	.678	.268	1.719
<b>BMI Categories</b>			7.860	3	.049			
<b>BMI: Underweight</b>	-1.209	.559	4.678	1	.031	.298	.100	.893
<b>BMI: Overweight</b>	-1.285	1.238	1.076	1	.299	.277	.024	3.133
<b>BMI: Obese</b>	-.124	.651	.036	1	.849	.883	.246	3.166
<b>Caption Categories</b>			3.209	2	.201			
<b>Caption: Colorguard</b>	.787	.546	2.074	1	.150	2.196	.753	6.408
<b>Caption: Percussion</b>	1.074	.621	2.992	1	.084	2.928	.867	9.889
<b>Total Years of DCI Experience</b>	-.693	.233	8.839	1	.003	.500	.317	.790
<b>Constant</b>	3.977	2.839	1.962	1	.161	53.337		

*Notes:* Sex is for males compared to females.

BMI is for healthy compared to the category listed in each row.

Caption is for brass compared to the caption listed in each row.

**Table 5:** Logistic regression predicting likelihood of injury based on age, sex, BMI category, caption, and total years of DCI experience for the 2019 season.

	<i>B</i>	SE	Wald	<i>df</i>	<i>p</i>	Odds Ratio	95% CI for Odds Ratio	
							Lower	Upper
<b>Age</b>	-.032	.133	.059	1	.808	.968	.746	1.256
<b>Sex</b>	-.341	.504	.458	1	.498	.711	.265	1.909
<b>BMI Categories</b>			.183	3	.980			
<b>BMI: Underweight</b>	-19.767	22826.523	.000	1	.999	.000	.000	.
<b>BMI: Overweight</b>	-.251	.604	.172	1	.678	.778	.238	2.543
<b>BMI: Obese</b>	-.269	.731	.136	1	.713	.764	.182	3.201
<b>Caption Categories</b>			3.445	2	.179			
<b>Caption: Colorguard</b>	1.121	.678	2.732	1	.098	3.067	.812	11.581
<b>Caption: Percussion</b>	1.405	.789	3.173	1	.075	4.075	.869	19.116
<b>Total Years of DCI Experience</b>	-.103	.163	.397	1	.529	.902	.655	1.243
<b>Constant</b>	-.816	2.720	0.090	1	.764	.442		

*Notes:* Sex is for males compared to females.

BMI is for healthy compared to the category listed in each row.

Caption is for brass compared to the caption listed in each row.

**Table 6:** Crude Odds Ratios (OR), Adjusted Odds Ratios (Adjusted OR), Confidence Intervals (CI) for 2018 and 2019 for demographic variables of interest.

	2018			2019		
	Crude OR (95% CI)	Adjusted OR (95% CI)	<i>p</i>	Crude OR (95% CI)	Adjusted OR (95% CI)	<i>p</i>
<b>Sex</b>			0.41			0.50
Males	Reference	Reference		Reference	Reference	
Females	1.671 (0.826 to 3.403)	0.678 (0.268 to 1.719)		1.800 (0.858 to 3.776)	0.777 (0.293 to 2.058)	
<b>Age (years)</b>	0.891 (0.709 to 1.119)	0.851 (0.654 to 1.107)	0.23	0.910 (0.719 to 1.151)	0.985 (0.761 to 1.274)	0.81
<b>BMI</b>			0.05			0.98
Underweight*	0.575 (0.064 to 5.173)	0.298 (0.100 to 0.893)		0.392 (0.020 to 7.840)	0.804 (0.247 to 2.618)	
Healthy weight <sup>†</sup>	Reference	Reference		Reference	Reference	
Overweight <sup>‡</sup>	2.076 (0.886 to 4.864)	0.277 (0.024 to 3.133)		0.884 (0.339 to 2.302)	0.000	
Obese <sup>§</sup>	3.194 (1.160 to 8.800)	0.883 (0.246 to 3.166)		1.390 (0.435 to 4.431)	0.728 (0.175 to 3.033)	
<b>Caption</b>			0.20			0.18
Brass	Reference	Reference		Reference	Reference	
Colorguard	1.878 (0.854 to 4.128)	2.196 (0.753 to 6.408)		1.611 (0.705 to 3.693)	2.386 (0.715 to 7.960)	
Percussion	0.568 (0.216 to 1.496)	2.928 (0.867 to 9.889)		0.395 (0.124 to 1.259)	3.351 (0.788 to 14.252)	
<b>Total Years of DCI Experience</b>	0.573 (0.387 to 0.849)	0.554 (0.366 to 0.839)	0.003	0.940 (0.671 to 1.218)	0.875 (0.635 to 1.205)	0.53

\*Underweight = Less than 5<sup>th</sup> percentile according to CDC Guidelines for Child and Teen BMI Categories

<sup>†</sup>Normal or Healthy Weight = 5<sup>th</sup> percentile to less than 85<sup>th</sup> percentile according to CDC Guidelines for Child and Teen BMI Categories

<sup>‡</sup>Overweight = 85<sup>th</sup> to less than the 95<sup>th</sup> percentile according to CDC Guidelines for Child and Teen BMI Categories

<sup>§</sup>Obese = 95<sup>th</sup> percentile or greater according to CDC Guidelines for Child and Teen BMI Categories

## **APPENDICES**



**APPENDIX A:**

Problem and Purpose Statement, Operational Definitions, Assumption, Delimitation,  
Limitations, Specific Aims, Independent Variables, Dependent Variables

## **Problem and Purpose Statement**

Drum and Bugle Corps is a physically demanding form of the performing arts and literature is lacking within this population. The minimal research available suggests marching band has evolved into a high demand activity that consists of strenuous and physically demanding efforts for participants involved. Thus far, limited self-reported data has been the only form of data collected and lacks reliability. Due to self-report data collection lacking reliability, healthcare professional-documented clinical data can help determine accurate musculoskeletal injury occurrence in a World Class drum corps and provide more insight on the prevalence of injuries occurring. Therefore, the purpose of this study is to determine the season-specific injury prevalence and identify factors associated with musculoskeletal injuries in a conveniently selected sample of a single World Class Drum and Bugle Corps in the United States over the course of two seasons, in order to increase the awareness of injury within this unique population.

## **Operational Definitions**

Acute Injury: Loss or abnormality of musculoskeletal structure or functioning resulting from an isolated exposure to physical energy during drum corps activity that is diagnosed by a Certified Athletic Trainer as a medically recognized injury.

Alternate member: a member of the drum corps who does not have a contract and does not have a permanent spot on the field. These individuals can sub in place of contracted members who are injured or unable to participate during rehearsal or performance. Members who are strictly alternate members will not be used in this study unless they are given a contract for the summer.

Caption: the highest-level grouping of drum corps members categorizes based-on primary instrument/implement: percussion, colorguard, brass

Competition: an activity or condition of competing against several other world class drum corps. All corps are judged and scored based on their quality of performance.

Competitive Season: The competitive season starts the first day of Spring Training towards the end of May until the completion of Drum Corps International (DCI) Championships at Lucas Oil Stadium in Indianapolis, Indiana in the beginning of August.

Chronic: Loss or abnormality of musculoskeletal structure or function resulting from a pre-existing injury that is diagnosed by a Certified Athletic Trainer as a medically recognized injury.

Date of Injury: date in which an injury has occurred. If the injury is an overuse case, this date will be recorded as the first day the member was affected while participating in a drum corps related activity.

Date of Return to Participation: the date a member returns to drum corps related activities with full participation and no restrictions. If the member has modifications in place this does count as returning to full participation.

Date of Resolution: the date a drum corps member no longer has any restrictions placed on them during a drum corps related activity.

Days of Participation Missed: the number of days a member is unable to participate due to a musculoskeletal injury

Days of Participation Modified: the number of days a member has missed due to an injury. Modified participation counts as any time a member is unable to participate in a drum corps related activity with full participation. This includes but is not limited to missing a rehearsal,

missing a performance, modified physical training, modified rehearsal, and modified performance.

Drum and Bugle Corps: is a musical marching unity consisting of brass instruments, percussion instruments and color guard. Subjects in this study will be from one single drum and bugle corps who traveled around the United States and are recognized by Drum Corps Internationals (DCI) as a World Class organization. There may be 154-members contracted for the season.

Drum Corps International (DCI): is a governing body for junior drum and bugle corps based in Indianapolis, Indiana. DCI is responsible for developing and enforcing rules of competition, and for providing standardized adjudication, at sanctioned competitions throughout the United States and Canada. It is the largest governing body of drum corps.

Ensemble Rehearsal: a rehearsal that involves all captions working on elements of the drum and bugle corps show

Exposure: for any contracted drum and bugle corps member who is at risk for injury, exposure is the number of days the subject practices in any related drum corps activity: physical training, rehearsal, or performance.

Healthcare Provider: is a person or company that provides a health care service to members.

Referred healthcare providers (e.g. nurse's, MD, DO's) may vary over the course of the study due to geographical location, but the Certified Athletic Trainer (AT) for the Drum Corps will remain the primary healthcare provider. The AT will be onsite and available 24 hours a day and 7 days a week over the competitive season.

History of Injury: This will consist of a previous occurrence of injuries with specifics to location of injury, severity of injury, etc. This question will appear on the pre-participation form prior to the start of the season. History of injury will also be asked at all initial evaluations of an injury.

Injury: Loss or abnormality of musculoskeletal structure or functioning resulting from drum corps activity that is diagnosed by a Certified Athletic Trainer as a medically recognized injury, regardless of time loss or need for intervention.

Drum Corps Captions: (Percussion, Colorguard, Brass) related instruments are followed:

Percussion: Members in the percussion ensemble are comprised of 2 sections: battery and front ensemble.

- Battery: Marching Percussion members who are the rhythmic interpretation of the mood. Bass Drum, Tenor (Quads) Drum, Snare Drum, Cymbals
- Front Ensemble Pit: Melody of the drumline and grounded instruments: bells, marimbas, vibraphones, xylophones, timpani

Colorguard: Members of the corps who integrate marching and dance techniques using a variety of instruments and weapons during performance: flags, rifles, sabers as well as a dance line. The members interpret the music through their work, expression, and emotion. Often members are required to move props during the show and conduct costume changes.

- Flag: Members of the drum corps who uses flags 75% of the time are considered colorguard flag members vs. dance line or colorguard members who predominantly use weapons (e.g. sabers or rifles) The flag is attached to a long pole and can come in a variety of lengths, colors, widths and can be throw in the air, spun, or move in a variety of ways.
- Rifles: solid or hollowed-out lightweight wood instrument simulating a rifle. This weapon can be thrown or spun in a variety of manners.

- Sabers: mimics a heavy cavalry sword with curved blade and a single cutting edge and can be thrown or spun in a variety of ways by colorguard members
- Dance Line: members of the colorguard who predominantly dance (approximately  $\geq 75\%$  of the show time) and do not use weapons such as sabers and rifles but do spin flags and provide interpretive movement to the show.

Brass: Contracted members play a variety of brass/horn instruments: Trumpet, mellophone, baritone/euphonium, tuba

Drum Major: a leader of the drum corps who stands on a podium conducting the entire drum and bugle corps at rehearsal and shows. They have the responsibility of keeping all the members in time and on beat during rehearsal and performances.

Marching/Contracted Member: a member who has signed a drum corps contract and is counted as a subject

Musculoskeletal Injury: (see: Injury)

Non-Time Loss Injury: an injury that does not impede or require modifications to a member's participation with drum corps related activities in anyway

Overuse Injury: loss or abnormality of musculoskeletal structure or functioning resulting from repeated bouts of physical load in association with drum corps activity that is diagnosed by a Certified Athletic Trainer as a medically recognized disease or syndrome.

Performance: Any competition sanctioned routine involving set-up or warm-up activities involved before or after the performance. Performances are between 8-12 minutes long and consist of choreographed sequences in front of judges during an organized competition.

Physical Training: typically occurs in the morning and consists of a dynamic warm-up, strengthening, and conditioning to help ensure members are physically conditioned for the day's physically demanding challenges.

Prevalence: All new or existing musculoskeletal injury cases during a single 3-month Drum Corps season / Total number of Drum and Bugle Corps members during a single 3-month Drum and Bugle Corps season \* 100

Rehearsal: Members of the corps are practicing their choreography, visuals, sequence in order to prepare for performances. Each rehearsal can be broken down into sectionals where each caption practices their own parts: Brass, Colorguard, Front Ensemble, Battery and can take place several times a day. Each rehearsal block is considered one single rehearsal instance.

Re-injury: any time a member of the drum and bugle corps sustains the same injury after already sustaining or suffering from the injury previously in the competitive season.

Sectional Rehearsal: rehearsal time in which each session is in their own section and may even divide into sub sections. Example: percussion might have a sectional rehearsal, but they then break out into battery and front ensemble and then battery might break into subsections (snare drums, tenor drums, bass drums, etc.)

Sprain - an injury to a ligament caused by the disruption of its fiber due to either an acute trauma or repeated/sustained stress over an extended period of time.

Spring Training: A period where all members of the corps are working on developing the beginning parts of the show. Spring Training typically lasts approximately three weeks and is located at various areas geographically.

Strain - an injury to a muscle caused by an extreme stretch or unsustainable muscle contraction.

Can also be due to continued and worsening muscle spasm leading to decreased strength and range of motion. Can be caused by an acute traumatic event or from repeated stresses over time.

Time Loss Injury: any injury that resulted in a member of the corps not being able to participate in physical training, rehearsal, and/or performances for one or more days.

Time Lost: number of days for which a member is not able to participate in physical training, rehearsal, and/or performances due to an injury.

Time Modified Injury: any injury that resulted in a member of the corps being able to continue to participate but not to their full capacity, in physical training, rehearsal, and/or performances for one or more days.

Time Modified: number of days for which a member is not able to participate fully in a drum corps related activity: physical training, rehearsal, and/or performance due to an injury.

Visual Rehearsal: a specific rehearsal time where members are marking out their places on the field and coordinating movements for the show. This is a time where members must pay attention to detail as this is rehearsing the visual effect of the show and working on specific choreography. There is no playing of instruments during this time.

Warm-Up (Competition or Performance): prepares drum corps members for the show. This includes but is not limited to: physical warm-up/stretching, visual warm-up, music/sectional warm-up.

## **Assumptions**

1. The corps' athletic trainers diagnose injuries reliably and accurately
2. Honesty of participants to report to the athletic trainer(s) should they experience an injury



3. Injuries reported are only from participating in a drum and bugle corps activity
4. Electronic Medical Records (EMR) will be reliable and HIPAA and FERPA compliant

### **Delimitations**

1. Only musculoskeletal injuries will be recorded.
2. Subjects will be from three major caption categories of performers: brass, percussion, and color guard.
3. Individuals who serve only as alternate members were not be part of the study.
4. Members who are not fluent in English will be excluded from the study.
5. Exposure hours will be obtained using previously recorded daily corps schedules.
6. Member attendance of physical training, rehearsals, and performances will be tracked daily.
7. The study will be conducted in the United States.
8. The study will be conducted within a single World Class Drum Corps International drum corp.
9. Time loss will be calculated separately for number of rehearsals and number of performances.
10. Subjects will be between 15-22 years old who were active members and from the same drum and bugle corps.
11. If an injury occurred to both sides of the body, this will be recorded as one single injury instead of two separate injuries.
12. All subjects included in the study will have been contracted members from the same drum and bugle corps

## **Limitations**

1. Healthcare provisions may vary based on where a drum corps is geographically located at the time of injury or consultation, as well as based on member health insurance benefits.
2. Subjects may be hesitant to report injuries. This limitation could include members not reporting to corps medical staff, as well as members falsely denying injuries when corps medical staff directly inquire with them.
3. Limited control over the amount or frequency of rehearsal.
4. Limited control over differing exposure levels between captions of subjects.
5. Environment varies considerably across captions and across the course of the season.
6. Membership rosters are not consistent from year-to-year.
7. Choreography is different each year and varies by intensity and difficulty.

## **Specific Aims:**

*Specific Aim 1:* Determine the season-specific injury prevalence of musculoskeletal injury within a World Class Drum and Bugle Corps across two competitive seasons.

*Specific Aim 2:* Identify factors associated with musculoskeletal injuries in a single World Class Drum and Bugle Corps across two competitive seasons.

## **Independent Variables:**

1. Grouping:
  - a. Caption

- i. Brass
  - ii. Colorguard
  - iii. Percussion
- b. Sex at birth
  - i. Male
  - ii. Female
- c. BMI Category
- d. Total years of DCI experience

**Dependent Variables:**

- 1. Musculoskeletal Injury
  - a. Yes
  - b. No

**APPENDIX B:**  
Review of Literature

## Review of Literature

Varied approaches for identifying injury, gathering data, and interpreting findings complicate the study of outcomes in sport injury epidemiology. Sports and dance injury experts have echoed the need for more standardized methodology in injury reporting.<sup>7,10,11</sup> Bronner et al.<sup>7</sup>, Liederbach et al.<sup>9</sup>, and Russel et al.<sup>55</sup> have all suggested developing a more comprehensive injury reporting mechanism for dancers specifically. Yet, many other performing artists lack injury surveillance and injury awareness entirely.

Researchers in the sports medicine and occupational field have developed surveillance systems which evaluate the efficacy of injury prevention strategies.<sup>7,8,10</sup> These surveillance systems discuss improvements in tracking injury trends; rates and severity; recognizing risk factors; and assessing the efficacy of injury prevention strategies. Bronner et al.<sup>7</sup> conducted a comprehensive surveillance of professional dancer injuries including a screening during the pre-season with specific attention to intrinsic and extrinsic factors, as well as injury occurrence during the pre-season. Tracking external risk factors involves quantifying exposure to specific environmental demands. Measuring activity exposure is important in order to understand injury epidemiology and has become significantly more specified over recent decades within the athletics injury literature.<sup>39</sup> However, the dance community still has no harmony existing for injury surveillance standardization.<sup>7</sup>

Since the 1970's, injury surveillance programs have been established predominantly by sports organizations and have two different systems of reporting injuries. The National Collegiate Athletic Associated Injury Surveillance System, established in 1982, is one of the most comprehensive instruments to track injury in North America.<sup>7-9</sup> This instrument is electronic tracks injury occurrences and consists of three components; pre-season intrinsic risk

factor screenings of otherwise healthy individuals, assessment of extrinsic risk factors and injury occurrence reporting system.<sup>7</sup> The second system for reporting injuries is the National Athletic Injury Reporting System (NAIRS)<sup>9,56</sup>

Healthcare providers have made efforts to prevent injuries within the dance population and have one injury reporting system call International Performing Arts Injury Reporting System (IPAIRS)<sup>57</sup> and this articles injury definition is based on if there was time lost from activity and if so, how much time was lost.<sup>56</sup> In 2004, the International Association for Dance Medicine and Science (IADMS) created this Standard Measuring Consensus Initiative for recommendation for: health screening for dancers, uniform reporting of injuries, and an assessment of dancers functional capacity.<sup>9</sup> Though there has been a push for uniformity within the sports and dance population, other performing art cohorts still lack a standard measuring consensus protocol.

Injuries occur in all populations and may occur due to human (intrinsic) causes or a result to hazards in the athletic setting (extrinsic factors) or, as is usually the case, from a combination of both factors.<sup>9</sup> One of the challenges in addressing sport and dance musculoskeletal injury rates is the lack of common definitions of injury.<sup>31-33</sup> During athletic activity injury exposure can be defined as the duration or number of events during which a participant is at risk of injury.<sup>7</sup> Length of exposure reporting refers to time injury on task (risk). There are two primary methods of defining exposure in sports: activity-based and time-based. For sport athletes, activity-based exposure is predominantly described as engaging in a game or practice and is calculated for each individual athlete within the categories of practices or game events. Time-based exposure is classified as practice or competition hours. Calculating injury rates is based on the number of injuries per 1,000 hours of sport participation<sup>58</sup> and exposure is often defined based on the user

of the system.<sup>9</sup> This is the unit of risk introduced in sports such as football (soccer) and rugby by many European researchers.<sup>58,59</sup>

When comparing sports exposure to dance exposure, it is important to note the differences between the two activities. Activity-based exposure for dancers is based on the hours of participation in dance-related activities such as rehearsals, performances, and dance classes. Although collecting injury exposure should be based on an individual's unique exposure experience, this is a difficult standard for researchers to follow within dance cohorts. Due to immense variation of schedules between dancers – to a much more significant degree than most sporting cohorts – this becomes extremely challenging to record.<sup>7,9</sup> Though this is the ideal way of collecting exposure in order to accurately portray injury rates, dance researchers have more commonly gathered injury exposure based on group collection.<sup>7</sup> Dancer's perform multiple events within a day which is unlike sports exposure where practice and game days are typically separate. Therefore, in dance, hours of exposure is more commonly recommended rather than event exposure for calculating injury.<sup>33,51</sup> This is important to point out because researchers are unaware of the number of hours one individual accumulates and is at risk of injury.

In dance, a concept of injury “time-loss” can lead to under-evaluating injuries in groups with fewer lessons, rehearsals, or performances, as well as minor injuries that may not lead to loss of time. It is difficult to understand patterns of underlying issues by tracking only time-loss injuries and Bronner et al.<sup>33</sup> suggested tracking “transient injuries” without time-loss to assist with understanding all types of injuries or complaints by dancers. Bronner et al.'s study discussed work-related musculoskeletal injuries (MSI) and reported only 0.48 injuries/1000 hours of exposure with time loss averaging 0.16 injuries/1000 hours which is very low when analyzing. Bronner et al.'s research article did not track complaints without time-loss, giving reason as to

why Bronner et al.<sup>7</sup> suggests research is missing underlying patterns of problems or injuries. Secondly, injury rates are developed based off retrospective self-report injury collection and do not discuss time-loss or they do not represent all dance exposure related activity. Instead of self-report records being collected for data collection, health professionals should be the primary data collectors for MSI injuries but often still are deficient in collecting time-loss.<sup>60</sup>

MSI are one of the most prevalent and physically disabling types of injuries across any generation, gender, and ethnicity worldwide. Although MSI is traditionally thought to pertain to “traditional” sports such as soccer, American football, and baseball, Beckett et al.<sup>1</sup> estimates approximately 27,000 individuals develop a musculoskeletal injury every year while participating in marching band or color guard within the United States.<sup>1</sup> Therefore, it is of a paramount importance to understand and recognize performing artists as athletes. While performing arts medicine knowledge is expanding, as evidence by the dance literature discussed above, there is still limited research on the prevalence of MSI within the greater sphere of performing artists. This review of literature aims to appraise the evidence regarding prevalence and characteristics of injury in non-traditional performing arts cohorts while elucidating the knowledge gap as to the need of medical attention in a unique “at risk” population.

### **Performing Arts Medicine**

Performing artists are athletes, and medical support is essential to ensure participants’ safety and well-being, but often support is not provided. Unlike traditional sports, performing artists frequently do not have access to key medical personnel such as athletic trainers, sports psychologists, sports nutritionists, a team physician, physical therapists, etc. Generally, performing artists, such as dancers and musicians, take little time off and often do not have medical professional coverage which can increase the risk of injury.<sup>61</sup> Professionals in sports



medicine are an important asset for filling this care gap by implementing existing knowledge of treating traditional sports while helping with injury prevention, nutrition, and understanding the particular needs of performing artists.

One of the most physically demanding performing arts disciplines with regard to the musculoskeletal system is ballet. Much of the current literature concentrates on ballet and modern dance at the elite or professional level due to the elevated injury rates. There are approximately 1.7 to 6.7 injuries per dancer each year with a prevalence of 67%-95% of injuries occurring per contract year.<sup>62-65</sup> The most common types of injuries that occur in dancers are overuse injuries with the foot and ankle being the most common site of injury.<sup>62</sup> The reason for a high incidence of overuse injuries in this population is due to the highly repetitive movements utilized and the comparatively high number of hours practicing and performing with limited days off.<sup>62</sup> Dancers (and a majority of performing artists) do not experience an off-season as many other traditional sports do, which may also contribute to these patterns. Injuries in general could be noted and even prevented if athletes had access to medical professionals that could promote early preventative measures and rehabilitation. Injuries could then be prevented rather than the current models which typically instead lead to exacerbation.

### **Collegiate Marching Band Injuries**

MSI occur among all types of athletes and have been researched in many “traditional” sports teams but there is a lack of literature within the performing arts particularly across high school and college organizations. Beginning in 1840, the University of Notre Dame in South Bend, Indiana was the first university to operate a marching band. In 1887, Notre Dame’s marching band first appeared during a football game, marching in a traditional military block formation.<sup>24</sup>

Athletes in marching band are at an high risk of injury due to the high demand, complex physical activity it requires.<sup>25</sup> Mehler et al.<sup>28</sup> studied injury occurrences self-reported by 337 University of Michigan band members (199 males and 138 females) and found that 83.3% of participants had experienced an injury at practice over the marching band season. Injury was defined as “any malady for which a band member sought medical evaluation and potential treatment that may or may not have required time missed from practice or performance.”<sup>28</sup> This study reported that the highest occurrence of injuries took place from August to September. In conclusion, the study noted 100 injuries (55.9%) taking place during 102.2 hours of practice and performance combined. Of the injuries, lower extremity injuries consisted of 85.5% of all injuries and ankle being the highest with accumulating 35% of those injuries tracked.<sup>28</sup> Mehler et al.<sup>28</sup>, Kilanowski<sup>27</sup>, and Beckett et al.<sup>1</sup> reported MSI rates range from 27-87.7% and illnesses were between 22-34%. The impact of upper and lower extremity injuries in marching band was also illustrated by Harmon<sup>66</sup> and reported members having 36% upper extremity pain, 22% lower extremity pain, and 58% back pain after a 10-month season.

In relation to extrinsic factors and high temperatures effecting marching band members, Sharma et al.<sup>67</sup> conducted a study on an urban University marching band, dance team, and cheer squad members and discussed the effect of diet and cardiovascular risk. This study estimated the athletes exercise at an intensity of 4.5-6 metabolic equivalents (METs) where vigorous activity is categorized as a 6 MET.<sup>68</sup> Although band members perform at a vigorous level, they are highly understudied in terms of dietary habits, fitness levels, and can be forgotten when looking at if they are at risk for cardiovascular disease.<sup>67</sup> This study concluded stating there was a high percentage of members from the marching band had poor dietary intake and put them at a higher risk for developing cardiovascular disease.

## **High School Marching Band Injuries**

Over the last 100 years in America, marching band has been a large part of music education.<sup>24</sup> In the United States, high school and college band members participating in Marching Band; however, most people do not understand the physical challenges of this type of activity. Cowen's<sup>69</sup> study on marching band physical activity reported band members took an average of 8,340 steps at practicing and 14,000 steps on game day, calculating to about 7 miles per game day while Edwards<sup>70</sup> found members of the drumline worked as hard as professional football players with heart rates over 200bpm and VO<sub>2</sub> over 40 mL/kg/min. Both Edward's<sup>70</sup> and Cowen's<sup>69</sup> studies provide more understanding of the physical demands of marching band members. High school marching band is another level of strenuous activity and the incidence of overuse injuries has been noted in limited previous studies<sup>26,27</sup>. In relation to injury occurrence, one must understand the requirements of the activity. The amount of rehearsal and practice time, field characteristics, and upper extremity injuries from holding an object for several hours a day should all be taken into consideration.<sup>26</sup> Researchers Zetterburg et al.<sup>18</sup> and Bejjanni et al.<sup>19</sup> have found playing musical instruments has an high rate of developing several physical injuries and especially MSI's due to its physically taxing demands.

High school marching band has evolved considerably over the years and has progressively increased intensity including more rigorous practice and performance demands at a regional and state level.<sup>27</sup> It is estimated that 95% of public high schools offer marching band in their high schools and many of those bands compete at the state or regional level.<sup>27</sup> Kilanowski et al.'s<sup>27</sup> retrospective study examined a high school marching band camp over the course of two years and investigated types of injuries and illness that occurred using a health clinical visit log format. Specifically, 27% of lower extremity injuries were found in 2005 and 35% in 2006,

making this the most common type of MSI to take place over the course of the marching band season.

Due to the prevalence of musculoskeletal injury in high school marching band, the National Athletic Trainers' Association has recognized the need for medical attention and has created safety guidelines for those involved within the activity. A portion of the guidelines established discuss: the need for gradual increase in physical activity prior to the start of rehearsals; provision of a general health exam before the season; healthy food consumption; wearing light clothing in hot environments; and adequately hydrating<sup>27</sup> Though these guidelines help build a foundation for safety and well-being of the high school band member, these guidelines are vague and lack specificity. With the known incidence of injury in marching band amongst high school and college marching arts, there should be further detailed regulations and clear procedures to support the safety of marching band members.

### **Military Marching Band Injuries**

Military band is another unique area within the marching arts where MSI frequently occurs due to long hours of exposure and repetition of playing instruments while marching.<sup>53</sup> Military bands consist of musicians and vocalists who are full-time members of the armed forces and highly skilled professionals in their artistic areas.<sup>71</sup> The U.S. Army band consists of 6 different units; Blue Jazz Ensemble, A Chorale, Concert Band, Ceremonial unit, String unit and a chorus and has several rehearsals and performances per year.<sup>71</sup> With the high physical and mental demands of rehearsals and performances, the band members encounter numerous MSI per year.<sup>71,72</sup>

Knapik et al.<sup>71</sup> studied military bands using a survey approach in 2004 and 2005, and found that 43.9% of band members encountered an MSI in 2004 and 52.7% encountered an MSI in 2005. In 2004, there were 90 soldiers with a total of 151 new injuries diagnosed and 504 follow up visits. In 2005, 152 new injuries and 439 follow up appointments occurred. This demonstrated a significant correlation of injury occurrence and severity. Risk factors to incurring a MSI included: practice durations, higher BMI's, and a history of previous injury.

### **Drum Corps**

Drum Corps is a unique activity that orchestrates sport, competition, art, and music. This integrative activity attracts thousands of individuals worldwide. This activity stems back to the 19<sup>th</sup> century when these groups began solely with fife players and drummers. After the First World War, veterans formed Drum Corps to march in patriotic events and in 1971 the activity grew in popularity. Drum Corps International (DCI) was established and currently maintains organizational affiliations in many locations in the United States and other countries.<sup>73</sup> Later, horn players, previously known as bugles, gave depth to the group and were there to assist the fife players and drummers with playing breaks during performances.

Modern day drum corps consists of thousands of participants and has three main sections: brass, percussion and colorguard.<sup>74</sup> Drum Corps only use brass instruments instead of the 19<sup>th</sup> century when they used woodwinds and now individuals playing percussion now march on the field.<sup>29</sup> Colorguard members, as well as all marching band members, often do not receive medical care for the high demands the sport activity on the body.<sup>74</sup> The colorguard members' routines consist of difficult choreography with weapons, which can pose a danger to themselves and others around them, by spinning, tossing, and flipping several types of equipment (e.g., rifles, sabers, and flags) to provide captivating visuals to audience.<sup>74</sup> Mehler's<sup>28</sup> study discussed

colorguard members and marching band members and stated that during a practice there was an injury rate of 0.7 to 1.0 injuries per hour, suggesting that there is a high chance of injury occurrence. Harmon et al.<sup>66</sup> reported numbness, tingling, loss of sensation and motor control deficits in colorguard members during practice or performance. Due to this underserved population as whole and the increase risk of injury, it is clear this area needs adequate medical care coverage.

Drum Corps is divided into two separate age ranges: junior corps and senior corps. Junior corps have an age barrier whereas a senior drum corps does not have an age limit. Drum Corps activities take place predominantly during the summer months between May and August. This time comprises the competition season. Each drum corps has auditions and rehearsal camps between approximately November and April annually, with individuals traveling from all over the world to attend. During preseason practices, marching members, brass players, percussion, colorguard, perform precise choreography, march at a pace of approximately 135 steps per minute<sup>68</sup> and carry instruments as heavy as 45 lbs<sup>26</sup> for hours exceeding 12 hours per day. Touring destinations during the complete season depend on the corps but generally span across numerous states and regions of the continental United States.

Performing arts medicine is a moderately new specialty and is essential for dancers, gymnasts, ice skaters<sup>75</sup>, and individuals involved in marching band as well as drum corps. Performing arts medicine is vital to aid participants' understanding in proper biomechanics, injury prevention, and overall health and wellbeing. Dommerholt et al.<sup>75</sup> study on performing arts medicine discusses musicians and their high risk of developing overuse injuries. Due to highly choreographed gestures and modified postures while holding instruments, drum corps participants are put at a higher risk of injury when compared to traditional band performances.<sup>76</sup>

Drum corps members have a complex combination of physical abilities that are needed to be a member of a drum corps. To safely and effectively be a member of a drum corps, all individuals of drum corps, especially those who play larger instruments, such as percussion or tubas, must have coordination, endurance. Coordination takes place when trying to learn drill and having to navigate their bodies and instruments around other participants. Strength is needed due to having to carry around heavy instruments/weapons/flags while marching. While endurance is essential due to the amount of repetitive movements they perform while practicing or performing. If participants do not come from a background of understanding the physical challenges drum corps, there is a high chance of musculoskeletal injuries occurring. Injuries can arise due to the amount of hours drum corps practices and performs or if they do not come in with strength, coordination, and endurance training. Not only is the literature provided limited, the information does not give adequate support for the high demands, such as the number of hours practiced in a day, the instances of injuries and illness, intensity of rehearsal, vigorous travel schedule and high stress placed on an individual.

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# Jennifer L. Pohlman

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## EDUCATION

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- Indiana University** | Bloomington, IN 2019 - 2021
- **Master of Science:** Kinesiology with emphasis in Athletic Training
  - CAATE-Accredited Post-Professional Athletic Training Program
- Clarke University** | Dubuque, IA 2014 - 2018
- **Bachelor of Science:** Athletic Training
  - **Minor:** Biology
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  - Performing Arts Activity – Choir Member 2014 – 2018
- University of Dubuque** | Dubuque, IA 2012 – 2014
- Major: Exercise Science - transferred credits to Clarke
  - Performing Arts Activity – Choir Member 2012 – 2014

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## PERFORMING ARTS RESEARCH

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- Indiana University** | Bloomington, IN
- **Master's Thesis:** “*The Prevalence and Correlates of Musculoskeletal Injury Among World Class Drum and Bugle Corps: A Cross-Sectional Study*”
    - Planned manuscript submission to *Medical Probl Perform Art*.
    - Planned free communications abstract submission to the National Athletic Trainers’ Association’s 2021 Clinical Symposia.

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## PROFESSIONAL EXPERIENCE

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- Indiana University – Contemporary Dance Theater** | Bloomington, IN 2020 – 2021  
Head Athletic Trainer - *Performing Arts Medicine*
- Served as the primary certified athletic trainer for the contemporary dancers providing athletic training services to an underserved population in an emerging setting
  - Utilized SportsWareOnLine Injury Tracking Software for documentation of injuries, treatments and rehabilitation protocols to produce injury reports and progress individuals back to dance
  - Provided and developed home exercise programs (HEP’s) and health, wellness infographics for dancers in order to educate dancers on proper care and progression of their bodies and injuries
- Indiana University – COVID-19 Tester** | Bloomington, IN 2020- 2021
- Processed nasal swab samples for rapid mitigation testing for Indiana University Bloomington’s Campus
  - Pre-screened subjects before proceeding to Vault Saliva testing
- Indiana University – Ballet Dancers COVID-19 Tester** | Bloomington, IN 2021
- Collected nasal swabs, processed tests, and cleared participants for ballet dance activities daily for spring semester

**Indiana University - Jacobs School of Music** | Bloomington, IN 2019 - 2020  
Head Athletic Trainer – *Performing Arts Medicine*

- Inaugural Performing Arts Athletic Trainer for Jacobs School of Music for 13,000 potential musicians, faculty, and staff members
- Led development of initial clinical space, including planning, supply ordering, and subsequent inventory
- Developed performer education materials and workshops for injury prevention and wellness promotion
- Documented medical information using SportsWareOnLine Injury Tracking Software

**Indiana University – Athletic Training Education Program** | Bloomington, IN 2020 - 2021  
Preceptor for Master of Science in Athletic Training Students

- Supervised and mentored Master of Science in Athletic Training undergraduate students to help advance and develop their clinical skills

**Indiana University – Raas Royalty Indian Dance Competition** | Bloomington, IN 2020  
Athletic Trainer / First Aid (PRN)

- Provided first aid and emergency services for one of the most prestigious Indian dance competitions across the country
- Evaluated all injuries and medical ailments for all 200+ visiting dance performers

**Varsity Cheerleading Sports Camp** | Cincinnati, Ohio 2020  
Athletic Trainer / First Aid (PRN)

- Provided first aid and athletic training emergency services for varsity cheerleading camps for 100+ athletes ranging from 4-20 years of age

**Drum Corps International (DCI)** | Dubuque, IA 2018 - Present  
Head Athletic Trainer

- Coordinated healthcare services for corps across 16 states of continuous travel for three months annually
- Functioned as first responder and evaluated all injuries and medical ailments for 150 performers
- Managed and advised the daily workload of 150 athletes rehearsing 8-12+ hours daily
- Arranged transportation of all performance athletes to clinics / hospital in various areas of the country
- Documented all medical interactions thoroughly via EMR (electronic medical records) system
- Participated in the Marching Music Health and Wellness Project clinic in San Antonio, Tx
- Advised the director and caption heads on member status and recommendations for health maintenance through consistent daily communications

**Barton College – Men’s and Women’s Swimming** | Wilson, North Carolina 2019  
Athletic Trainer - *Sports Medicine NCAA Division II Athletics*

- Men’s Swimming Conference Carolinas Champions
- Women’s Swimming runner-up Conference Carolinas Champions
- Hosted home swim meets and traveled to Conference Carolinas Meet
- Provided medical care at practices and home events, daily athletic training room coverage, and rehabilitation of acute, chronic, and post-operative injuries
- Documented medical information using SportsWareOnLine Injury Tracking Software

**Barton College – Men’s and Women’s Tennis** | Wilson, North Carolina 2019  
Athletic Trainer - *Sports Medicine NCAA Division II Athletics*

- Provided medical care at practices and home events, daily athletic training room coverage, and rehabilitation of acute, chronic, and post-operative injuries
- Documented medical information using SportsWareOnLine Injury Tracking Software

**Barton College – Men’s and Women’s Tennis** | Wilson, North Carolina 2019  
Athletic Trainer - *Sports Medicine NCAA Division II Athletics*

- Provided medical care at practices and home events, daily athletic training room coverage, and rehabilitation of acute, chronic, and post-operative injuries
- Documented medical information using SportsWareOnLine Injury Tracking Software

**Loras College – All-Sports Camp** | Dubuque, IA 2018  
Assistant Athletic Trainer - *Sports Medicine*

- Performed musculoskeletal assessments, preventative measures, and referrals for children ages 6-14 attending camp consisting of approximately 600 kids / week
- Contacted parents of children about injury / illness in emergency & non-emergency situations

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### PROFESSIONAL ATHLETIC TRAINING VOLUNTEER EXPERIENCE

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**Indiana University – ROTC Air Force** | Bloomington, IN 2021  
Athletic Trainer – *Military Medicine*

- Provided emergency and acute care for Indiana University’s ROTC Air Force during physical training

**Indiana University - Dance Team & Marching Hundred Band** | Bloomington, IN 2019 - 2020  
Athletic Trainer - *Performing Arts Medicine*

- Provided pregame treatments and on-field emergency care for several home Indiana Football games

**Indiana University – Men’s and Women’s Swimming and Diving** | Bloomington, IN 2020  
Athletic Trainer - *Sports Medicine NCAA Division I Athletics*

- Assisted with BIG Ten Swim and Dive competition

**Indiana University – Track and Field** | Bloomington, IN 2019  
Athletic Trainer – *Sports Medicine NCAA Division I Athletics*

- Assisted as an athletic trainer for the Indiana University’s Track and Field Hoosier Invitational
- Provided emergency and acute care for Indiana’s Track athletes and visiting teams

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### OTHER JOB EXPERIENCE

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**Indiana University - Group Exercise Fitness Instructor** | Bloomington, IN 2019-2021

- Lead a multitude of strength, endurance and agility group exercise classes to Indiana University’s students, faculty, staff, and Bloomington residents including: Bootcamp, Core, Pure Strength, Cycle, etc.

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**CERTIFICATIONS / LICENSES AND MEMBERSHIPS**

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- Indiana Professional Licensing Agency (IPLA) – (36003175A) AT License 2019 - Present
- Board of Certification - Certified (BOC# 2000033817) 2018 - Present
- National Provider Identifications – (NPI #1811555394) 2019 – Present
- Graston Technique® (M1) - Provider 2019 - Present
- America Red Cross CPR / AED Basic Life Support Provider – Certified 2014 - Present
- American Council on Exercise – Certified Expected August 2020
- National Athletic Trainers’ Association (NATA) – Member 2015 - Present
- Great Lakes Athletic Training Association (GLATA) -Member 2015 - Present
- Iowa Athletic Trainers’ Society (IATS) – Member 2015 - Present