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BODY COMPOSITION ASSESSMENT RESULTS AND PREDICTING INJURY PATTERNS IN COLLEGIATE MUSICIANS

BY

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THESIS APPROVED:

Chair, Advisory Committee

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ELLEN P. REINHOLD

Submitted to the Faculty of the Graduate School of
Eastern Kentucky University
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ABSTRACT

Objective: It is known that a higher body mass index (BMI) is associated with increased risk of injury, but it is unknown whether there is an association between increased risk of injury and body composition. Currently the data comes from competitive sports, with little data in performing arts, specifically marching band. The primary aim of this study was to determine if body composition assessments can predict musculoskeletal injury (MSI) occurrence in marching band participants. *Methods*: Body composition was measured using a duel X-ray absorptiometry (DXA) scan at the beginning of both the fall 2018 and 2019 seasons. Data on injuries were compiled from the electronic medical records (EMR) system kept by the athletic trainer. Prior to getting a DXA scan, subjects were weighed on a Tanita scale to determine initial body weight. Then subjects were scanned by the DXA to gather body composition data. *Results*: After using statistical software to run predictive analysis, it was found that body composition was not a predictor of injury. The only variable that was predictive of injury (p=0.043) was sex, females being 2.9 times more likely to be injured. *Conclusion*: In this sample of band performers, body composition was not predictive of injury. This was not consistent with previous literature which found that a higher BMI was a risk factor for sustaining an MSI. Additionally, this association between injury and BMI does not mean that there is causation and could be misleading in injury predictions based off of BMI. Clinically, the knowledge that female band performers are 2.9 times more likely to be injured could help influence the clinician's on field injury prevention decisions.

Keywords: injury, body composition, marching band

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Introduction

In the world of sports, musculoskeletal injuries (MSI) are linked to sport and recreational participation[1]. It is well known in the literature that there are modifiable and non-modifiable risks of injury accompanying participation[1]. One of these potential modifiable risks is body composition, the percentage of fat, bone, muscle, and water that comprise the human body. Examples of body composition metrics that clinicians, researchers, and experts often focus on include the determination of lean mass (the subtraction of body fat from body weight) and fat mass (amount of fat relative to body weight). It has been hypothesized that, with increased amounts of fat mass, there may be an associated lower level of fitness and neuromuscular control[1]. If increased levels of fat mass can negatively affect fitness and neuromuscular control, then they could also increase the risk of sustaining an MSI[1]. For example, as a modifiable risk factor relating to injury, body mass index (BMI-a calculated estimate derived from an individual's height and weight) was predictive of on-ice injury in hockey players[2]. Similarly, Gribble et al. identified that football players with higher BMI had increased risk of sustaining lateral ankle sprains[3]. While lower levels of fitness and decreased neuromuscular control, an increased risk of injury can occur in an athletic population with higher BMIs[1]; there have been few investigations have been attempted in the performing arts, specifically marching band.

Recently, Beckett et al. reported that a higher BMI was found to be a risk factor for sustaining an MSI as a direct result of participating in a collegiate marching band[4]. However, BMI is determined from height and weight measurements rather than measurements of body composition. The concern is that BMI can be misleading since it does not take into account the various types of body tissue in the calculation. For example, two individuals of the same weight and height would be classified similarly based on the BMI thresholds. Yet the two individuals could diverge when examining the percentage of fat mass versus lean mass, i.e., one individual being comprised of more muscle and the other, more fat. This suggests that although an association between BMI and injury risk may exist, it is unknown if more accurate measures of body composition would yield the same finding.

Furthermore, epidemiology of injury occurrence or risk of injury in marching band performers has not been completely established. The first reported injury data for band performers was made available in 1996 demonstrating that lower extremity injuries, primarily ankle injuries, were common in marching band[5]. Although this report provided some insight into injury occurrence for marching band performers, we do not know how body composition could relate to injuries, unlike various studies in athletic population which have focused on injuries, injury rates, and BMI[6,7].

With such gaps in the performing arts and marching band literature, data on injuries related to body composition may assist clinicians in identifying risk factors and potential injury. This information could help in the development of prevention programs or other related interventions for reducing the occurrence of MSI. Therefore, the purpose of this study was to determine if body composition assessments could predict MSI occurrence in marching band performers. The hypothesis of the study was that a higher percentage of fat mass or lower percentage of lean mass would be predictive of sustaining an injury during the marching band season.

Literature Review

Background on Marching Band

Marching bands across the country have become a traditional part of the college football game day experience[8]. Much like for the football team, game day starts early and ends late for most marching bands. Pre-game activities could include beginning the day with a morning rehearsal, followed by participating in a pep rally, and concluding the afternoon with a march around tailgate locations. After the pre-game performance, the marching band performers take to the stands to perform during breaks in play and then go back onto the field for a halftime performance. These performances generally range from 5-10 minutes of almost continuous performance, with varying levels of choreographed complexity. Following the halftime performance, the marching band performers return to the stands to play intermittently for the duration of the game, often ending the evening with the college/university's fight song. The demands placed on performance-based activities of the marching band are similar to the duration, frequency, and intensity required by traditional athletic events[8]. Game day kickoff dictates the length of the day for marching band. Depending on if members get a break in between morning rehearsal and the rest of the day's activities, there can be little time for performers to recover from one performance to the next, eat meals, or manage injuries[9]. This lack of recovery and sub-optimal diet may lead to sustaining other injuries or other health complications[9]. With game day placing high demands on both athletic teams and marching bands, each prepares with a pre-season camp.

One method of preparing for the rigors of game day performance is the implementation of an intensive practice regimen similar to athletics. Marching bands have been known to utilize preseason training similar to sports teams' preseason practices in order to prepare for the upcoming marching season[10]. Like an athletic preseason, which can be a preventative measure to reduce the number of in-season injuries[11, 12] by re-engaging athletes in sport and physical activity, a marching band's preseason is meant to familiarize participants with the march step, fundamentals, drill and condition. In addition to increased physical activity, the march step employed by the director, it could be causing injury instead of preventing it. Founded at the University of Michigan, high-step march was associated with a greater rate of injury[5]. Researchers proposed this was due to the high impact created by the type of march and this could lead to overuse and stress injuries[5]. While not all collegiate marching bands implement the high step for every performance, it can be taught over the preseason camp as part of fundamentals. A collegiate marching band's preseason camp can start 1-3 weeks prior to classes beginning in the fall and include several two-a-days. Performers engaging in a week-long marching band camp may be exposed to at least 100 hours of drill, playing, and working on fundamentals. Unless there is inclement weather, practices are held outside with few water breaks or recovery time. Much like an outdoor athletic team, a marching band is exposed to extreme heat indexes over their preseason camp. This physically challenging and immersive camp is intended for performers to master marching basics and have pre-game drill and music set by the beginning of the semester.

Compared to preseason, practices during the traditional academic semester are not as frequent or lengthy, but they continue in moderate to high intensity[5, 8, 13]. Similar to athletic teams, an intense preseason schedule for marching band leads into regular practices occurring throughout the week. Practices are as frequent as every day or as little as three days a week, averaging 2 hours a session. Practices include multiple repetitions of marching with and without playing music, with few water or recovery breaks[8]. With no decrease in intensity between preseason and in-season, participants have little time for recovery and become susceptible to illness and injury[14].

Another similarity to athletics includes the relationship between physical symptoms and exposure[11, 15, 16,17]. The risk of getting instrument playing-related pain increases with the amount of playing one does[8]. Marching bands can be composed of both music majors and non-music majors. For music majors, marching band is generally a course requirement and is not the only time they are actively playing an instrument. Music majors consistently report more playing-related pain than their non-music major counterparts both during marching rehearsal and after marching rehearsal (Visual Analog Scale of pain reports Woodwind: Majors m= 3.18, Non-majors m=3.07; Brass: Majors m=2.92, Non-majors m=2.39; Percussion: Majors m=2.94, Non-majors m=1.83; Guard: Majors m=7.30, Non-majors m=4.20)[8]. According to Hatheway and Chesky, this could be due to the amount of time spent playing an instrument outside of marching band[8], such as in a methods or studio class. For music majors, marching band is often not the only musical ensemble they must be a part of.

Ensembles such as orchestras or concert bands are required for classes, as well as pep band in some cases. Pep band's season overlaps with the marching band season, putting that much more stress on the student. In unpublished work, it has been shown that both majors and non-majors are exposed to about 200 hours from the time they start preseason marching band camp until the end of their marching season. Although the association between exposures and injury has been well-documented in the athletic world[15], there is little to no literature on exposure rates and their association with injury for marching band performers.

Current literature on playing-related pain in the performing arts is specific to individual instruments, orchestras, or concert bands[17, 18, 19, 20, 21]. This narrow view of performing arts is not easily generalized to the population of marching band. While some of the literature does include instruments that are used in a marching band, like the flute or percussion instruments[18, 19], the populations from those studies are professionals and in an orchestra or concert band, both of which are much more sedentary compared to a marching band. This lack of pertinent literature to marching band injuries could hinder the ability of administrators to be able to accurately inform their marching band performers about the risks associated with performing in that ensemble. Without that knowledge performers are not able to act accordingly and take preventative measures against acute or chronic injuries associated with playing[22]. The gap in the literature also leaves out pertinent information that a healthcare professional needs to accurately care for their patients.

While they are an active group, most of the members in performing arts have not had any courses on nutrition or physical self-care[22]. Even with the frequency, intensity, and time commitment similar to any athlete, performers in marching band have the mentality that they are not athletes[23] and live sedentary lifestyles. The current culture of marching band is that if one experiences playing-related pain, ignore it[23]. If pain persists, the mentality is that the pain will never subside[23]. This mentality is anecdotally seen in sports when a collegiate athlete that does not wish to be pulled from play, but most athletes have a healthcare professional working closely with them. Marching band is currently an emerging setting for most healthcare professionals[13], which leaves this demographic without the proper personnel to help with the injuries sustained. It is possible that in this population the incidence of injury is unknown primarily because band performers do not traditionally have a healthcare professional, such as an Athletic Trainer. This lack of clinicians could create an environment rife with untreated injuries.

Predisposing Factors to Marching Band Injuries

When competing at any level of sport, there are risk factors associated with play and injury occurrence. For performers in marching band those risks correlate to a higher BMI, less physical activity, previous injury, and practice duration[14]. Musculoskeletal injuries and playing related pain show up with frequency in several studies specific to the instrument played[24], postural deviations[25], and type of march step employed by the director[5,8]. A systematic review done by Kok et al. on MSIs in musicians found a high rate of reported injuries, with their recommendation being that subsequent studies should focus more on risk factors for musicians rather than the frequency and types of injuries seen in professional musicians[26]. Previous studies researched the instrument played relating to specific injuries, heat illness, or general fitness[27]. Musculoskeletal injuries are widely researched and have set standards of care in the sports world, with healthcare professionals available at various levels of play. Performing arts, on the other hand, is an emerging setting; most often the performers have no immediate access to a healthcare professional. This lack of access to a healthcare professional could create a lack of research, which would in turn feed into a lack of evidence-based practice and set standards of care for these individuals.

While types and frequencies of MSIs are frequently seen in the literature relating to performance-related pain in musicians[24, 26, 28], environmental concerns, uniforms, and levels of physical activity outside of marching band are also important factors that play a role in health and injury. Marching band is known for its iconic, traditional marching uniforms. While this uniform is a part of the marching band culture and experience, it presents a health hazard for the performers with the excessive number of layers the performers must wear on days with a high heat index. The National Athletic Trainers' Association (NATA) position statement on Exertional Heat Illnesses states that: "Excessive clothing or equipment decreases the body's ability to thermoregulate and may cause greater absorption of radiant heat from the environment"[29]. The uniforms worn by marching bands across the country on game day satisfy the conditions laid out in the position statement and therefore any marching band performer's body will have a harder time cooling itself, increasing the risks for a heat-related illness.

One of the major modifiable risks associated with injuries for marching performers is having a higher BMI[14]. Knapik et al. documented injuries of professional musical performers of the US Army Band to determine injury risk factors. Variables that were associated with higher injury risk were higher BMI, less physical activity, prior injury, unit, functional group, and practice duration[14]. While we know that BMI is an associated risk factor for marching performers and athletes, the association between body composition and injury prediction is unknown.

Musculoskeletal injuries and disorders are widely researched in the sports world[6, 11]. Kilanowski studied the frequency of injuries, over the course of a high school marching band camp, and supported the claim that healthcare professionals "should consider the athleticism required for this activity" when working with a marching band[10]. Even though they are not traditional athletes, what a marching band does is highly physical and should have the same healthcare coverage as any athlete playing their sport, considering their needs are just as great[30]. With marching band being an emerging setting for healthcare professionals, there are no studies of body composition and injuries. Using body composition as a predictor of injury could help improve clinical standards pertaining to injury prevention in marching band. Therefore, the purpose of this study was to determine if body composition assessments could predict MSI occurrence in marching band performers.

Methods

Prior to the beginning of practice and competition in the fall of 2018, an invitation was extended for the marching band performers from a single university to have their body composition analyzed as part of a free service offered by the Exercise and Sport Science Department. Each student's body composition was measured using the university-owned dual energy X-ray absorptiometry (DXA) scanner (GE Lunar Prodigy, Boston, MA [Figure 3]). The electronic medical record (EMR) notes maintained by the Athletic Trainer hired to work with the marching band were accessed in order to identify any general medical, environmental, or MSIs that were reported during the fall 2018 season. Data points from the DXA were correlated with injuries reported by the participant during the fall 2018 season. The variables of interest included injuries (type and location on the body) and the body composition of the subjects during the fall 2018 season.

To expand the population of interest, data points on injuries and body composition characteristics of the band were also obtained for the fall 2019 season for pre-existing and newly enrolled students. When a band performer arrived on campus for pre-season performance and training, the individual was informed about the body composition assessment option. If the band performer elected to have his or her body composition assessed, the individual was asked to sign an informed consent form, which outlined the study's goals and purpose, and a DXA waiver.

Only band performers who were medically cleared by the certified Athletic Trainer assigned to the band or the medical staff at the university's Student Health

Services for full participation were recruited for participation in the study. Other inclusion criteria that had to be met in order to participate in the study included ages 18-35; ability to read, speak, comprehend English; and medically cleared to participate in the marching band (per determination during pre-season physical examination). Exclusion criteria included body weight exceeding 350 lbs., not a participant in band, or women who were pregnant. If body weight exceeded 350 lbs., this excluded the performance of the DXA due to machine restrictions. If band performers were excluded from using a DXA due to the weight restriction, body composition was measured by a SOZO (ImpediMed bioimpedance spectroscopy system D2C, Brisbane, Australia [Figure 2]) device. If the performer was female, they were required to provide verification of a negative pregnancy test to the research team prior to participation in the testing procedures.

Each subject was provided a numeric code number, which served as the subject identifier for the duration of the study. Body weight was measured by a Tanita (Tanita SC-331S Body Composition Monitor, Tokyo, Japan [Figure 1]), which was input into the DXA software to provide more accurate measurements. The subject was instructed to take off all metal jewelry as well as shoes and socks to perform body weight measurements on a Tanita scale. Each point of contact—i.e., plantar surface of feet and palmar surface of hands--was cleaned using isopropyl alcohol. The subject had to input his or her body type, height, biological sex, and age on the Tanita's screen. He or she then stepped on to the Tanita scale to determine initial body weight. The Tanita then printed off a receipt with the subject's measured information (fat mass percentage, lean mass percentage, body weight, etc.), at which point the subject stepped off the scale.

Figure 1. Tanita Unit

Finally, subjects were measured using a DXA scanner (Figure 2). Individuals were instructed prior to arrival to wear tight-fitting clothing in order for the device to accurately assess body composition. The subject was asked to lie on their back on the device with arms at the side, hands flat to their sides/hips, and their eyes closed. The subject was informed to lie as still as possible during the scanning. The DXA is an open platform with a scanning arm elevated many feet above the platform. The scan would take between 10 and 20 minutes, depending on the size of the individual. Larger subjects were scanned twice if necessary so both sides of the body could be analyzed thoroughly. The measurements of interest taken by the DXA were body composition and bone mineral density. This included lean mass, fat mass, and distribution of fat mass about the body.

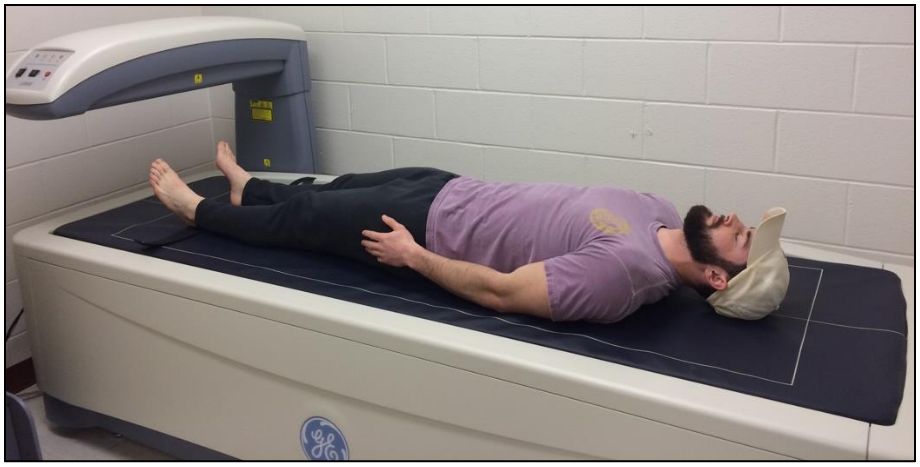

Figure 2. DXA Unit

If the subject was excluded from being measured by the DXA due to body weight exceeding 350lbs., they then had to create a user profile on the SOZO (Figure 3) mobile readout application as the alternative body composition measurement. Any identifying information that subjects had to input into the SOZO as a profile were changed so that it was unable to be traced back to them. Only the primary researcher would know what the adjustments made were. Examples include how a subject's name was reduced to initials, using their subject number as an identifier, and birthdate adjusted by a given number of days. The subject was then instructed to step onto the SOZO with hands placed on the horns of the plate at waist level and feet placed on a scale. The SOZO measured body composition, along with intra- and extracellular water, hydration status, and mineral content; data appeared on an iPad readout.

Figure 3. SOZO Unit

Data Analysis

Summary descriptive statistics for demographic items were calculated and reported as means and standard deviations for continuous variables while frequencies and percentages were reported for categorical variables. Participants were dichotomously categorized as suffering an injury that prevented full participation in marching band or no sustained injury for data analysis.

Pairwise comparisons (Table 1) and crude odds ratios were calculated next to determine if any of 15 variables of interest could be significant predictors of sustaining injury (Table 2). Multicollinearity was assessed via the calculation of variance inflation factors. Nine variables met or exceeded the variance inflation threshold of 2.5. Therefore, only 6 variables were entered into a forward stepwise binary logistic regression analysis (age, years in band, lateral/medial asymmetry, upper body asymmetry, lower body asymmetry, and sex). In order to keep the model statistically significant, the p-value of the model was monitored during the analysis. As the steps increased, the newly entered variable had to keep the model's p-value at ≤ 0.05. If variables added to the model created a statistically insignificant model ($p > 0.05$), the variable would be removed from the step in the developing model. Odds ratios, 95% confidence intervals (CIs), and Nagelkerke R^2 were examined to determine the strength of the model. The final adjusted model would be determined based on combinations of confounding and independent variables. All statistical calculations were performed using SPSS (version 26; SPSS, Inc., Chicago, IL).

Table 1. Crude Odds Ratios for Individual Variables for Predicting Injury

Variable	Unadjusted Beta	Adjusted Beta (Odds Ratio)	P-Value	95% Confidence Interval
Age (years)	-0.069	0.933	0.764	0.596, 1.463
Years in Band	-0.163	0.849	0.253	0.642, 1.124
Height (m)	-2.423	0.648	0.306	0.001, 9.205
Weight (kg)	0.008	1.008	0.492	0.986, 1.031
Body Mass Index (kg/m^2)	0.044	1.045	0.193	0.978, 1.116
Sex	-1.063	0.344	***0.043***	0.122, 0.967
Lean Mass (%)	-0.015	0.985	0.516	0.942, 1.031
Fat Mass (%)	0.014	1.015	0.514	0.971, 1.060
Bone Mineral Density Spine (g/cm^2)	1.369	3.390	0.379	0.186, 82.961
Bone Mineral Density Pelvis (g/cm^2)	1.774	5.895	0.276	0.242, 143.488
Bone Mineral Density Total (g/cm^2)	1.154	3.172	0.539	0.080, 126.331
Lean Mass Asymmetry (lbs)	-0.071	0.932	0.792	0.551, 1.575
Upper Body Asymmetry (lbs)	-0.096	0.909	0.847	0.344, 2.400
Lower Body Asymmetry (lbs)	0.091	1.095	0.683	0.708, 1.692
Fat Free Mass Index (kg)	0.085	1.089	0.327	0.919, 1.290

m=Meters; kg=Kilograms; cm=Centimeters; g=grams; lbs=pounds

Table 2. Body Composition Variables

	Lean Mass (%)	Fat Mass (%)	Bone Mineral Density Spine	Bone Mineral Density Pelvis	Bone Mineral Density Total	Lean Mass Asymmetry (kg)	Upper Body Asymmetry (kg)	Lower Body Asymmetry (kg)	Fat Free Mass Index (kg)
Non-injured (n=35)	61.55±12.34	35.15±12.61	1.16±0.16	1.14±0.15	1.27±0.14	0.19±.48	0.09±0.28	0.05±.58	16.97±.44
Injured (n= 28)	59.70±9.83	37.07±10.44	1.20±0.17	1.18±0.18	1.29±0.14	0.16±0.38	0.08±0.17	0.10±.46	17.77±2.84
P-value	0.521	0.519	0.385	0.277	0.545	0.796	0.85	0.689	0.326

g= grams; cm=centimeter; lbs= pounds; kg= kilograms

Results

Demographic variables are reported in Table 3. The population total of the band is 139 performers, with 72 (52%) identifying as male and 67 (48%) identifying as female. The study's demographics were similar to that of the population with 36 (57%) of the subjects being male and 27 (43%) of the subjects being female. While the injured group had a higher BMI (mean=30.84) compared to the non-injured group (mean=28.21), it was not statistically significant (p=0.191) at the p≤0.05 level. Comparatively, females had 42.1% fat mass (p=0.001) and 54.8% lean mass (p=0.002), while males had 30.3% fat mass and 66.2% lean mass.

Table 3. Descriptive Statistics for Demographic Variables

	Overall (n=63)	Non-injured (n=35)	Injured (n=28)	P-Value
Age (years)				
Mean (SD)	18.90±1.13	18.94±1.26	18.86±0.97	0.768
Height (m)				
Mean (SD)	1.172±0.11	1.73±0.10	1.70±0.12	0.311
Weight (kg)				
Mean (SD)	87.01±22.62	85.27±21.48	89.19±24.18	0.499
Body Mass Index (kg/m²)				
Mean (SD)	29.38±7.89	28.21±7.25	30.84±8.54	0.191
Years in Marching Band				
Mean (SD)	8.02±1.86	8.26±1.85	7.71±1.86	0.253
Sex				
Male	36 (57%)	24 (69%)	12 (43%)	
Female	27 (43%)	11 (31%)	16 (57%)	0.040

SD = standard deviation; m=meters; kg= kilograms

The predictor variable that was statistically significant ($p=0.043$) was sex (OR=2.909, 95%CI=1.034, 8.183). The logistic regression analysis generated a significant model with a Nagelkerke $R^2=0.09$ ($p=0.040$) that predicted the probability of an MSI, with the inclusion of sex as a variable in the equation. The resulting regression equation resulted in a 59% increase in the probability of suffering an MSI if female. An established prediction equation was utilized in order to determine the frequency of future injury occurrence based on the factors derived from the regression analysis. Equation: 59% (likelihood of musculoskeletal injury) = -0.693 (constant) + 1.068 (female)

Discussion

The current study identified that body composition is not a predictive factor for injury in its selected cohort of collegiate marching band performers. Populations in the literature relating to band performers have not been consistent and few compare to this study's interest in body composition and its potential to predict injury. Previous works have used military personnel[14, 31], high school marching band students[10], and other collegiate performing arts participants[5, 9, 13] as their populations of interest. Studies that focused on research in predicting injury and BMI came mostly from sports participants[2, 3]. The current study was novel because it used DXA compared to the previous listed literature, which all used BMI calculations and did not investigate body composition and injury. This lack of parallel made comparisons between the studies' hypotheses difficult. Although there are studies that have examined marching band as a population of interest, they only explored the epidemiology of injuries in marching band with no accounting for BMI or actual body composition assessments as predictive factors[5, 8, 10, 13]. Due to variance in populations, direct comparison between this study and others' populations is challenging. However, while there were differences between studies, one of the biggest similarities was gender demographics.

This study found that females were more likely to be injured than males. This is consistent with previous literature where investigations were performed in the areas of band performers[4, 5], sport[1, 33, 34], and military settings[14]. Related to marching band, Beckett et al. found that females were more likely to be injured than males ($p<0.001$)[4] whereas Mehler et al. found females had slightly higher reporting (females: 50.3% of the total injuries)[5]. Potential factors for why females have been identified as sustaining more injuries have included anatomical differences (such as Q-angle), weaker muscles supporting structures, more laxity to ligaments, and a predisposition to a lower bone density[33]. Although those factors reported by Mollayeva are related to the lower extremity, out of the 28 marching band performers injured in the current study, 10 of those injuries were lower extremity injuries (hip, knee, ankle, foot) whereas the remaining 18 were head and neck and upper extremity injuries. This suggests that injury occurrence in band could be cohort dependent, meaning that injuries occurring at one institution may not occur at another. It has also been hypothesized that women are more likely to report injury than men because of the social acceptance to admit vulnerability[34]. This would lend to the hypothesis that the female band performers were more likely to report subsequent injuries than their male counterparts, which could be why this study had more female self-reported injuries than males.

Although our body composition variables were not predictive of injury, during initial data analysis both males and females were grouped together in the injured category. Because of this combination, the differences between the injured groups, by sex, were not distinguished. Once we found that sex was predictive of injury, we looked at the metrics for each sex and found significant differences. Comparatively, females had 42.1% fat mass while males had 30.3% fat mass ($p=0.001$). Similarly, females had 54.8% lean mass while males had 66.2% lean mass ($p=0.002$). These findings help illustrate that body composition indeed differed between the sexes and that the females unfortunately had unhealthier levels of fat mass. Furthermore, these between group differences were only identified through use of the DXA, which suggests that body composition assessments may yield more robust results versus the popular yet inaccurate BMI calculation. The inaccuracy of BMI is likely due it generating a ratio, which does not account for the various types of body tissues. Clinically, this indicates that DXA scans could be used to help identify women more at risk for sustaining an injury.

While previous work identified BMI as a predictive factor for injury[1, 4, 5, 14, 31, 32, 35], theoretically using the gold standard for body composition assessment as we did in the current study should have yielded similar results. Beckett et al. also found that a higher BMI was a risk factor for sustaining an MSI as a direct result of participating in marching band (p=0.014)[4]. If the performer had a lower BMI (mean=24.27, ±4.46) they were less likely to sustain an MSI compared to those with a higher BMI (mean=25.07, ±5.76)[4]. Although there is statistical significance between groupings, the values are only separated by 0.80 kg/m^2, which would suggest a lack of clinical meaningfulness. In the literature suggesting that BMI is a risk factor, it may not actually be a risk factor based on what we found with DXA. Furthermore, our results yielded that BMI did not have an impact on predicting injury, even with an average BMI of 29.38 (±7.89). After further review of our data, 62% of all performers were in the overweight category or higher of BMI. Specifically, 17 band performers were in the overweight category of BMI (25-29.9) and 22 band performers were spread between the three obese BMI categories (30-34.9, 35-39.9, >40). It is possible that our data was not supportive of injury prediction based on higher BMIs because the BMI of the majority of the sample was in the upper categories. In other words, when there is less variation in BMI amongst a sample, the possibility of identifying a risk factor diminishes. Additionally, this association between injury and BMI does not mean that there is causation. While BMI and body composition did not predict injuries in this group, future studies should be done in athletic populations with DXAs as the measurement of body composition in order to verify the previous reports of BMI being a risk factor for injury in athletic populations.

The clinical implications of this study are three-fold. First, the marching band performers are an under-investigated population that now have body composition data. Second, while we did not find body composition to be a predictive factor, we did find that sex was predictive of injury. This makes clinicians more aware of possible injury, which is supported by previous literature in sports. We now know this holds true in the current study's marching band performers. Third, based on the current study's results, it was found that BMI was not an accurate predictor of injury, which could make future injury predictions based on BMI misleading.

Limitations

The data show that, in this population, body composition was not predictive of injury, unlike what was originally hypothesized. This was a convenience sample, based on self-reported injuries during two seasons of marching band. Anecdotally, most of the students had not had a healthcare professional work closely with their band. Thus, reporting any MSIs could be a new concept and potentiated non-reports, leading the data to be inaccurate regarding the true prevalence of injuries. We used this method despite the possible limitations because this was what the band performers would have normally done and this did not disrupt or change regular injury reporting. The population of the marching band also posed limitations. The band performers were not a representative sample of other collegiate marching bands, high school marching bands, or the drum corps. While this is the case, we used this population because it starts to fill a gap in literature relating to band performers, and this opens up the potential for other studies to be conducted in a similar fashion.

Conclusion

The intention of the study was to gather data on body composition as a predictive factor for injury to help improve clinical standards. In this sample of band performers, body composition was not predictive of injury. The only variable found to be predictive of injury was sex, with the odds of injury if the band performer was female was 2.9 times more than that of a male. With a continued gap in the literature, pertinent information such as clinical standards for a marching band are lacking. Further research could to consider band performers in different settings (college, high school, drum corps), their body composition, instrument specific injuries, comparisons to athletes, and what injuries they sustain.

References

1. Amoako A, Nassim A, Keller C. (2017, August). Body mass index as a predictor of injuries in athletics. *ACSM, 16*(4), 256-262.

2. Grant JA, Bedi A, Kurz J, Bancroft R, Gagnier J, Miller BS. (2014). Ability of preseason body composition and physical fitness to predict the risk of injury in male collegiate hockey players. *Sports Health, 7*(1), 45-51.

3. Gribble P, Terada M, Beard M, Kosik K, Lepley A, McCann R, Pietrosimone B, Thomas A. (2016). Prediction of lateral ankle sprains in football players based on clinical tests and body mass index. *AJSM, 44*(2), 460-467.

4. Beckett S, Seidelman L, Hanney W, Liu X, Rothschild C. (2015). Prevalence of musculoskeletal injury among collegiate marching band and color guard members. *Med Probl Perform Art, 30*(2), 106-110.

5. Mehler AS, Brink DS, Eickmeier KM, Hesse DF, McGuire JW. (1996, September). Marching band injuries. A one-season survey of the University of Michigan marching band. *Journal of the American Pediatric Medical Association*, *86*(9), 13-407. Retrieved from MEDLINE (8885602).

6. Dick RW. (2006, January). NCAA injury surveillance system: a tool for health and safety risk management. *Athletic Therapy Today, 11*(1), 42-44.

7. Diokno E, Rowe D. (2010). Medical and orthopedic conditions and sports participation. *Pediatr Clin N Am, 57*, 839-847.

8. Hatheway M, Chesky K. (2013, December). Epidemiology of health concerns among collegiate student musicians participating in marching band. *Med Probl Perform Art*, *28*(4), 242-251. Retrieved from CINAHL (107887931).

9. McConnell C, McPherson A, Woolf K. (2018). Competition level not associated with diet quality in marching artists. *International Journal of Sport Nutrition and Exercise Metabolism, 28,* 66-74.

10. Kilanowski JF. (2008, November). Marching athletes: injuries and illnesses at band camp. *MCN, 33*(6), 338-345.

11. Soligard T, Schwellnus M, Alonso JM, Nahr R, Clarsen B, Dijkstra HP, Gabbett T, Gleeson M, Hagglund M, Hutchinson M, van Rensburg CJ, Khan KM, Meeusen R, Orchard J, Pluim BM, Raftery M, Budgett R, Engebretsen L. (2016, July). How much is

too much? (Part 1) international olympic committee consensus statement on load in sport and risk of injury. *Br J Sports Med, 50*, 1030-1041.

12. Mugele H, Plummer A, Steffen K, Stoll J, Mayer F, Muller J. (2018, October). General versus sports-specific injury prevention programs in athletes: a systematic review on the effect on injury rates. *PLoS ONE, 13*(10), 1-16.

13. Moffit DM, Russ AC, Mansell JL. (2015, June). Marching band camp injury rates at the collegiate level. *Med Probl Perform Art*, *30*(2), 96-99. Retrieved from CINAHL (109809274).

14. Knapik JJ, Jones SB, Darakjy S, Hauret KG, Nevin R, Grier T, Jones BH. (2007, December). Injuries and injury risk factors among members of the United States Army Band. *American Journal of Industrial Medicine*, *50*(12), 951-961. Retrieved from MEDLINE (17979136).

15. Kerr ZY, Marshall SW, Dompier TP, Corlette J, Klossner DA, Gilchrist J. (2015, December). College sports-related injuries-United States, 2009-10 through 2013- 14 academic years. *MMWR, 64* (48), 1330-1336.

16. Omorou YA, Erpelding M-L, Escalon H, Vuillemin A. (2013, January). Contribution of taking part in sport to the association between physical activity and quality of life. *Qual Life Res, 22*, 2021-2029.

17. Steinmetz A, Moller H, Seidel W, Rigotti T. (2012, December). Playing-related musculoskeletal disorders in music students-associated musculoskeletal signs. *European Journal of Physical and Rehabilitation Medicine*, *48*(4), 625-633. Retrieved from MEDLINE (23138678).

18. Sandell C, Frykman M, Chesky K, Fjellman-Wiklund A. (2009, December). Playing-related musculoskeletal disorders and stress-related problems among percussionists. *Med Probl Perform Art,*(24), 175-180.

19. Lonsdale K, Laakso E, Tomlinson V. (2014, September). Contributing factors, prevention, and management of playing-related musculoskeletal disorders among flute players internationally. *Med Probl Perform Art, 20*(3), 155-162.

20. Baadjou V, de Bie R, Guptill C, Smeets R. (2017, August). Psychometric properties of the performing arts module of the Disabilities of the Arm, Shoulder, and Hand questionnaire. *Disability and Rehabilitation*, 1-7.

21. Dabholkar AS, Siddharth SB, Dabholkar TA. (2015, December). Playing related musculoskeletal disorders in guitarists. 542-545. Retrieved from ResearchGate.

22. Chesky KS, Dawson WJ, Manchester R. (2006, September). Health promotion in schools of music: initial recommendations for schools of music. *Med Probl Perform Art*, *21*(3), 142-144. Retrieved from EBCO: Music Index (MAH0001564755).

23. Newmark J, Lederman RJ. (1987, January). Practice doesn't necessarily make perfect: incidence of overuse syndromes in amateur instrumentalists. *Med Probl Perform Art*, *2*(4), 142-144. Retrieved from EBSCO: Music Index (MAH000498261).

24. Cayea D, Manchester RA. (1998, March). Instrument-specific rates of upper-extremity injuries in music students. *Med Probl Perform Art*, *13*, 19-25. Retrieved from EBSCO: Music Index (MAH0000844458).

25. Ohlendorf D, Wanke EM, Filmann N, Groneberg DA, Gerber A. (2017). Fit to play: posture and seating position analysis with professional musicians-a study protocol. *Journal of Occupational Medicine and Toxicology, 12*(5), 1-14. DOI: 10.1186/s12995-017-0151-z.

26. Kok L, Huisstede B, Voorn V, Schoones J, Nelissen R. (2015, November). The occurrence of musculoskeletal complaints among professional musicians: a systematic review. *Int Arch Occup Environ Health,* (89), 373-396. DIO: 10.1007/s00420-015-1090-6.

27. Harman SE. (1993, January). Medical problems of marching musicians. *Med Probl Perform Art*, *8*(4), 132-135. Retrieved from EBSCO: Music Index (MAH0000700416).

28. Steinmetz A, Scheffer I, Esmer E, Delank KS, Peroz I. (2014, January). Frequency, severity and predictors of playing-related musculoskeletal pain in professional orchestral musicians in Germany. *Clin Rheumatol,* (34), 965-973. DOI: 10.1007/s10067-013-2470-5.

29. Casa DJ, DeMartini JK, Bergeron MF, Csillan D, Eichner ER, Lopez RM, Ferrara MS, Miller KC, O'Connor F, Sawka MN, Yeargan SW. (2015, September). National Athletic Trainers' Position Statement: Exertional Heat Illness. *Journal of Athletic Training, 50*(9), 986-1000.

30. Bird H, Macdonald I. (2013, January). Expert care of the performing artist. *Clin Rheumatol, 32,* 421-423.

31. Rappole C, Grier T, Anderson M, Hauschild V, Jones B. (2017, August). Associations of age, aerobic fitness, and body mass index with injury in an operational army brigade. *Journal of Science and Medicine in Sport, 20,* S45-S50.

32. Janney C, Jakicic, J. (2010). The influence of exercise and BMI on injuries and illnesses in overweight and obese individuals: a randomized control trial. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 1-11.

33. Mollayeva T, El-Khechen-Richandi G, Colantionio A. (2018, January). Sex and gender consideration in concussion research. *Concussion, 03*(01), CNC51.

34. Kroshus E, Baugh CM, Stein CJ, Austin SB, Calzo JP. (2017, December). Concussion reporting, sex, and conformity to traditional gender norms in young adults. *J. Adolesc.* 2017;54:110–119.

35. Milanese C, Cavedon V, Corradini G, De Vita F, Zancanaro,C. (2015, January). Seasonal DXA-measured body composition changes in professional male soccer players. *Journal of Sports Sciences, 33*(12), 1219-1228.