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**The Prevalence of Musculoskeletal Injuries within the Center for Wellness in the Arts
at Marshall University**

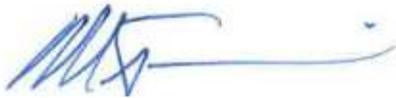
A thesis submitted to
the Graduate College of
Marshall University
In partial fulfillment of
the requirements for the degree of
Masters of Science
In
Exercise Science

by
Colin John Wakeman

Approved by
Dr. Mark Timmons, Committee Chairperson
Dr. Henning Vauth
Dr. Gary McIlvain
Mr. John Colclough

APPROVAL OF THESIS

We, the faculty supervising the work of Colin John Wakeman, affirm that the thesis, *The Prevalence of Musculoskeletal Injuries within the Center for Wellness in the Arts at Marshall University*, meets the high academic standards for original scholarship and creative work established by the Masters of Exercise Science and the College of Kinesiology. This work also conforms to the editorial standards of our discipline and the Graduate College of Marshall University. With our signatures, we approve the manuscript for publication.



4-30-2021

Dr. Mark Timmons, School of Kinesiology

Committee Chairperson

Date

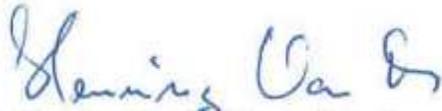


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ABSTRACT

Background: The demands on successful performing artists are two-fold. First, they have to perform at a high skill level for their specific art, such as theater, marching band, dance, and color guard. Second, they need to achieve the aesthetic demands of their discipline.

Musculoskeletal (MSK) injuries can impact either or both of these elements and affect their overall performance. If MSK injuries are not addressed early in a performer's career, they can develop into chronic problems that take performers out of rehearsals, practices, and performances.

Purpose: This epidemiological study aimed to investigate the prevalence of MSK injuries within the Center for Wellness in the Arts at Marshall University (CWA) and then compare the prevalence of MSK injuries in the published literature. The hypothesis was that the CWA would result in a lower prevalence of MSK injuries due to the collegiate age of the performers.

Methods: Investigators sorted through the published literature and found 24 studies or reviews that established a baseline prevalence of MSK injury outside of Marshall University's performing arts community. Investigators implemented a retrospective evaluation of data collected within the CWA to compare the prevalence of injuries within the performing arts at Marshall University to the published literature.

Results: The CWA reported less than expected injuries to the knee ($\chi^2 = 21.969$, $p < 0.001$), ankle ($\chi^2 = 12.931$, $p = 0.003$), calf ($\chi^2 = 11.253$, $p = 0.007$), foot ($\chi^2 = 22.039$, $p < 0.001$), lumbar spine ($\chi^2 = 30.613$, $p < 0.001$), shoulder ($\chi^2 = 42.726$, $p < 0.001$), thoracic spine ($\chi^2 = 5.045$, $p = 0.024$), hand/wrist/and finger ($\chi^2 = 55.181$, $p < 0.001$), upper arm/elbow/and forearm ($\chi^2 = 47.292$, $p < 0.001$), head and neck ($\chi^2 = 35.011$, $p < 0.001$), lower extremity ($\chi^2 = 181.967$, $p < 0.001$), and illnesses or ailments categorized as "other" ($\chi^2 = 7.506$, $p < 0.001$). Data analysis,

with a p-value greater than 0.05, resulted in no statistical difference between injury prevalence of the CWA data compared to the published literature. The CWA reported a greater prevalence of injuries to the hip ($\chi^2 = 2.274$, $p = 0.131$), thigh ($\chi^2 = 0.257$, $p = 0.611$), and upper extremities ($\chi^2 = 0.043$, $p = 0.835$) compared to the reported literature.

Conclusions and Practical Relevance: The CWA showed a lower prevalence of MSK injuries than the published literature in the epidemiological review. Implementing preventative medicine interventions earlier in a performing artist's career can reduce the detrimental impact of overuse injuries. This can result in prolonging the careers of performing artists and improving their health.

CHAPTER 1

INTRODUCTION

Musculoskeletal (MSK) injuries are prevalent in the performing arts more frequently than one might assume. Performing artists experience injuries and illnesses that can accumulate over years of intense training.[1] Productions that demand an aesthetically pleasing look create tremendous pressure and strain on the artists, both mentally and physically. Suffering an injury during a performance season may result in time lost from activity and an increased cost to the participant or organization. Performers dedicate themselves full-body to their craft just the same as any athlete in a traditional sense. Performers can pick up their crafts at a very young age. Musicians frequently practice and perform year-round to hone their skills. These years of training may result in overuse injuries that can be detrimental to a performer's career progression. Treatment associated with an injury may also be costly for the participant. Providing treatment and initiating preventative interventions early may reduce the number of injuries and associated costs.

Marshall University provides academic programs that allow young artists a chance to earn degrees within the performing arts. Students entering Marshall are mostly still young and may have no previous knowledge of healthcare programs or services available within the performing arts. Marshall University established the Center for Wellness in the Arts (CWA) in August of 2014, providing athletic training services for the performing arts population at the university. These medical services are provided in a variety of forms that include coverage of the marching band at football, being backstage at live theater and musical performances, and holding clinical hours for walk-in appointments. Knowing the prevalence of injuries in the performing arts allows healthcare organizations and professionals to help performers in the early stages of

their careers. The Athletic Trainers working with the CWA have maintained an electronic medical record of evaluating and treating the university's performing artists' injuries.

The purpose of this investigation was to complete a retrospective review of the CWA electronic medical records (EMR) to identify the prevalence and impact of MSK injuries in a collegiate-age performing arts population. Secondary comparisons of the prevalence of injury and injury treatment identified by the CWA to the existing literature was performed. While reviewing the literature, the authors of the current paper will bring to attention the age range of performers currently studied and what groups have been reported. This retrospective study reviews the services provided by the CWA, including the evaluation and treatment of the injury. The services provided will help support the need for preventative medicine at an earlier age, targeting the collegiate level or younger, which would help promote decreased healthcare costs and prolonged performing careers for performers of any background.

Research Problem

The prevalence of musculoskeletal injury and injury treatment within the performing arts at the collegiate level has not been fully reported in the literature. The current investigation examines the medical records collected over six years at the CWA to investigate the prevalence of MSK injuries among performing artists at a collegiate level, and whether patients received efficient medical treatment, if necessary.

Most performance-related injuries result from overuse and the excessive training these individuals go through from an early age.[2] Artists seek perfection in their work from an early age to please an audience. A correlation was found between the onset of symptoms and increased playing time multiplied by practice intensity.[2] This states that with an increase in playing time and the intensity of practice, you find an earlier onset of pathological symptoms and their

severity.[3] Much of the data collected over the past six years within the CWA were first-time college students who had not been exposed to the rigors of a university workload.

Descriptive Data Collected

This retrospective study investigates patient records from an electronic medical record database. Data extracted from the database, Core-AT, includes the number of patients who sought medical services from the CWA, as well as their discipline (e.g., theater, marching band, color guard, or dance), injuries reported in each group (e.g., sprains or strains), and more. Additional data examines time lost from activity, mechanism of injury, body region where the injury is located, how many of each injury has been reported, and the cost associated with treating injuries.

Hypothesis

H₀: The CWA provides a report on injury prevalence consistent with that reported in the literature for similar artists.

H_A: An alternative hypothesis is that the reported data shows a lower prevalence of injury for those from the CWA because of the collegiate performing artists' ages.

CHAPTER 2

LITERATURE REVIEW

The purpose of this investigation was to determine whether collegiate-aged performing artists at Marshall University have a lower prevalence of injury than non-collegiate performers. This study was conducted as a descriptive study reviewing the literature associated with the performing arts. Inclusion criteria for articles include anything covering dance, vocal arts, theater performers, marching band, and music majors; this incorporates participants within orchestras, symphonies, and ensembles. The literature review contributes to the investigation by reviewing published literature covering professional and amateur performers in different performance groups. The literature review covered information on MSK injury collected from performing arts medicine literature. Specifically, it includes injury data from the fields of dance, instrumental musicians, collegiate marching band, color guard, and theater performers. Within each group, literature has been collected to investigate MSK injuries that address acute, chronic, and encompass injuries that may affect a performer's day-to-day activity.

Injuries within the performing arts can truly hinder a performer's success. Performers expect perfection and are critiqued in front of the public eye, making functional health necessary.[1, 4, 5] We hypothesized that performing artists at Marshall University would experience less prevalence of musculoskeletal injuries than non-collegiate performers. Artists often begin their craft at a very young age and, as time goes on, the chronic stress of the performing arts can result in injuries. It would be advantageous to address unhealthy habits for young performers at an early age to determine whether this practice can result in less injury as they continue in their careers.

Search Strategy

The following databases were searched: PubMed, CINHALL, Ebscohost, and MPPA. In addition, other sources and reference lists of published papers were searched. The search terms included: performing arts; musculoskeletal injuries; prevalence; the prevalence of injury; injuries; musicians; dancers; stage actors; marching band; instrumentalists; performers; and actors. The following Boolean search strings were used:

- (“Musculoskeletal injury”) AND (“Performing arts” OR “Theatre” OR “Dance” OR “music”)
- (“Musculoskeletal injury”) AND (“prevalence”) AND (“performers” OR “marching band” OR “performing artists” OR “Orchestras” OR “symphonies”)
- (“Prevalence of injury”) AND (“instrumentalists” OR “musicians” OR “instrumentalists” OR “artists”)
- (“Injuries”) AND (“performing arts”)

Study Selection

The initial searches returned 239 published abstracts. From this collection of abstracts, 59 potentially relevant papers were identified. The next stage of the selection strategy involved examining each of the 59 screened abstracts and determining their eligibility for the review. In this stage, 59 full articles were assessed, and 35 articles were excluded. The literature selected for inclusion in the review references the prevalence of MSK injuries or playing-related musculoskeletal disorders (PRMDs) within the performing arts. Any paper that did not include epidemiological research was excluded during the study selection phase. Finally, 24 articles were selected for the structure of this epidemiological review. Tables 1–5 below provide summaries of the 24 papers selected for the review of the literature.

Authors	Group	Gender	age range (yrs)
Rothenberger 1988	Dancers	M 116/F 610	mean = male (32), Female (31)
Mehler 1996	Musicians, Marching band	M 89/F 90	College age
Shields 2000	Musicians, pianists	M 8/F 33	mean = 20.5
Pascarelli 2001	Computer users, musicians, and other	M 179/F 306	range = 15-79
Buckley 2006	Musicians, lower & upper strings	M 45/F 66	range = 10-87
Wiklund 2006	Musicians, lower strings	M 458/F 62	range = 33.04 ± 13.05
Furuya 2006	Musicians, pianists	F 203	range = 15-60
Kilanowski 2008	Marching band	M&F	High school
Brusky 2010	Musicians, bassonists	M 97/F 69	Not reported
Leaver 2011	British symphony orchestra	M 136/F 107	range = 23-64
Ackermann 2012	Professional Orchestral Musicians	M 185/F 192	range = 18-68
Wanke 2012	Musical Theater	M 20/F 17	avg 21.3 ± 2.15
Steinmetz 2013	Professional Orchestral Musicians	M 236/F 172	mean = 43.9
Kok 2013	Musicians and non-musicians	M 22/F 62	range = 18-30
Simon 2014	Modern and Ballet dancers	M 10/F 67	mean = 19.61 ± 2.53
Moffit 2015	Collegiate level marching band	M&F	Not reported
Beckett 2015	Collegiate Marching Band and Color guard	M 587/F 792	mean = 19.77
Berque 2016	Professional Orchestra Musicians	M 51/F 50	45 ± 10.83
Lonsdale 2016	Instrumental music students	M 43/F 55	range = 18-50
Costa 2016	ballet dancers	M 22/F 88	range = 34.1-41.2
Pellicciari 2016	Italian DanceSport Athletes	M 77/F 76	range = 24.4-26
Trentacosta 2017	Dancers, professional and student	M 565/F 1436	mean = 17.9
Ajidahun 2017	String Instrumentalist	M 38/F 76	range = 18-78
Ling 2018	Classical Piano students	M 29/F 163	mean = 20.5

Table 1. Demographics for included epidemiological literature.

Literature Summaries	
Musicians	
Mehler 1996 [6]	The study collected clinical data on injury occurrence to members of the University of Michigan Marching Band over the course of one season. The study resulted in a reported total of 179 injuries, and 153 (85.5%) were lower extremity.
Shields 2000 [7]	The purpose of this study was to investigate the prevalence of injuries among pianists in music schools in Ireland. The main goal of the study was to identify the main anatomical locations of reported injuries, commonly reported symptoms, and risk factors for the development of playing-related injuries. The most common location of injury was the wrist at 36.6% of reported injuries.
Pascarelli 2001 [8]	This review investigates work-related upper extremity disorders among computer users, musicians, and others. A main finding was that factors including repetitive forceful motions results in a postural deterioration. Most of the clinical findings were in the neck and upper back.
Furuya 2006 [9]	The purpose of the study was to investigate the prevalence of playing-related musculoskeletal disorders (PRMDs) among Japanese classical pianists of different age groups. Results showed that 77% of the pianists suffered from PRMDs in at least one body region.
Wiklund 2006 [10]	The aim of this cross-sectional study was to describe problems among guitarists and to investigate differences between type of guitar played. They also described the prevalence of musculoskeletal problems determined for the total group of guitarists. For all subjects, they found that 81% reported one or more musculoskeletal problems.
Buckley 2006 [11]	The study investigated the baseline prevalence, new onset of injury, and possible correlations with technical and postural deficits within non-classical recreational instrumentalists.
Kilanowski 2008 [2]	The purpose of the study was to describe the frequency and types of injuries sustained by high school marching band members. The most reported musculoskeletal injury was in the lower extremities.
Brusky 2010 [12]	The purpose of this study was to investigate PRMDs in bassoon players. They found that of the women who participated in the study 100% of them reported a PRMD. The men still reported PRMD, but it only amounted to 78% of the male participants. The commonly reported injuries were found in the hands, arms, and wrists.
Leaver 2011 [13]	This review assessed the musculoskeletal pain in elite professional musicians from British symphony orchestras. The main findings showed that musculoskeletal pain is common in elite professional musicians and that it can impact mental health and performance anxiety.
Ackermann 2012 [14]	The paper reports on the musculoskeletal pain and injury in professional orchestral musicians in Australia. Injuries varied by instrument, but they were localized around the back, upper limb and neck, and neck alone. The factors that contributed to injury included training and playing load.

Musicians	
Steinmetz 2013 [15]	The work investigated playing-related musculoskeletal disorders (PRMD) in professional orchestral musicians in Germany. The study focuses on the necessity of therapeutic intervention to help treat and prevent common PRMD among professional musicians. PRMD can lead to performance disability, sick leave, or potential ending of a career.
Kok 2013 [16]	The purpose of this questionnaire was to compare the frequency of musculoskeletal complaints between musicians and non-musicians. Results supported that musculoskeletal complaints are more common among musicians. This is supported by musicians reporting greater issues with upper extremities including hands, wrists, left elbow, shoulders, neck, jaw, and mouth.
Moffit 2015 [3]	The aim of the study was to record marching band camp injuries over the course of 1 week (10 field practices) to determine injury rate for preseason. For the week of preseason there was a total of 191 injuries reported in 1,540 practice exposures. The study supported the idea that marching band is a strenuous activity and deserves to be considered for emerging practices of health care professionals.
Beckett 2015 [17]	The report investigates the prevalence of musculoskeletal injuries within collegiate marching band and color guard members. In this patient population it was reported that lower extremity injuries are more common and there was a higher percentage of women reporting MSI.
Berque 2016 [18]	This prevalence study investigates playing-related musculoskeletal problems (PRMP) among professional orchestra musicians. The study reported that 77.2% of the musicians who participated have had lifetime prevalence of PRMP.
Lonsdale 2016 [19]	The study reviews playing-related health problems among instrumental music students at a University in Malaysia. The study showed that 28.9% of the students reported having current playing related pain in any given body part.
Ajidahun 2017 [20]	The study investigates musculoskeletal problems among string instrumentalists in South Africa. Of the reported musculoskeletal problems, they reported having the most issues with the trunk and both shoulders.
Ling 2018 [21]	The study investigates playing related musculoskeletal disorders (PRMD) among classical piano students. Results showed that 35.8% of piano students reported having PRMD. Common affected body regions include arm, fingers, and wrist pain.
Actors/ Dancers	
Rothenberger 1988 [22]	The study investigates the prevalence and types of injuries in aerobic dancers. The study supports that injuries among aerobic dancers happen mostly to the shins, low back, and ankles.
Wanke 2012 [23]	The pilot study surveyed health problems in musical theater students. The study concluded that many factors contributed to support the need for injury prevention. They noted that the region of the body that was injured the most were the lower extremities (65.3%).

Actors/ Dancers	
Simon 2014 [24]	The purpose of this study was to identify the prevalence of chronic ankle instability (CAI) in a student dance population. They wish to support that it is important to educate dancers and instructors of the importance of recognizing CAI and seeking medical care.
Costa 2016 [25]	The study investigates the characteristics and prevalence of musculoskeletal injury in professional and non-professional ballet dancers. The study supported that musculoskeletal injury among the dancers was correlated to time of practice.
Pellicciari 2016 [26]	The article investigates injuries among Italian DanceSport Athletes. The article supports that DanceSport athletes predominately present injuries among the lower limbs and spine.
Trentacosta 2017 [27]	The systematic review identifies and describes hip and groin injuries in dancers. They shared that hip and groin injuries are an important health concern for dancers on any level. These injuries are shown to be more prevalent in professional than student dancers.

Table 2. Summaries of the epidemiological studies included in this review.

Actors/ Dancers	participants	knee	ankle	hip	calf	foot	thigh	lumbar spine	shoulder	thoracic spine	hand/wrist/fingers	upper arm/ elbow	head/neck	Upper extremity	Lower Extremity	Other	Total cases
Rothenberger 1988	726	113	150	36	79	67	29	158	67	31	25	20	56	—	380	19	1230
Wanke 2012	37	7	7	17	14	12	7	19	7	2	2	2	2	—	—	—	98
Simon 2014	77	—	54	—	—	—	—	—	—	—	—	—	—	—	—	—	54
Costa 2016	110	18	50	11	—	15	21	15	5	—	3	—	6	—	—	—	144
Pellicciari 2016	102	—	—	—	—	—	—	19	—	—	—	—	—	9	74	—	102
Trentacosta 2017	2001	—	—	—	—	—	—	—	—	—	—	—	—	—	345	—	345
Total cases	138	261	64	93	94	57	211	79	33	30	22	64	9	799	19	1973	
%	5	9	2	3	3	2	7	3	1	1	0.7	2	0.3	26	0.6		

Table 3. Prevalence of musculoskeletal injuries among actors and dancers.

Musicians	participants	Anatomical Regions											Upper extremity	Lower extremity	Other	Total cases	
		knee	ankle	hip	calf	foot	thigh	lumbar spine	shoulder	thoracic spine	hand/wrist/fingers	forearm/upper arm/elbow					head/neck/trunk
Mehler 1996	179	34	54	2	3	32	1	9	2	—	5	—	3	—	20	14	179
Shields 2000	159	—	—	—	—	—	—	—	4	4	24	5	4	—	—	—	41
Pascarelli 2001	485	4	4	1	—	—	—	8	5	—	36	7	1	—	5	38	109
Buckley 2006	111	—	—	—	—	—	—	4	19	—	14	3	—	—	—	—	40
Fjellman-Wiklund 2006	520	—	—	—	—	—	—	208	198	209	787	240	141	—	—	—	1783
Furya 2006	203	—	—	—	—	—	—	—	94	—	170	116	86	—	—	—	466
Kilanowski 2008	402	—	—	—	—	—	—	—	—	—	—	—	—	17	168	—	185
Brusky 2010	166	—	—	—	—	—	—	—	63	—	47	89	49	—	4	—	252
Leaver 2011	243	—	—	—	—	—	—	125	124	—	79	50	135	—	—	210	723
Ackermann 2012	377	—	—	—	—	—	—	—	—	94	—	R 84/L 55	63	—	—	187	483
Steinmetz 2013	408	—	—	—	—	—	—	207	R 213/L 225	96	473	R 83/L 69	177/297	—	—	379	2219
Kok 2013	83	10	5	5	—	7	—	33	48	16	21	8	60	—	—	—	213
Beckett 2015	1379	207	—	83	—	83	—	41	55	—	69	14	—	—	41	469	1062
Lonsdale 2016	98	—	—	—	—	—	—	44	108	46	82	84	39	61	—	68	532
Berque 2016	101	—	—	—	—	—	—	8	23	7	20	27	14	—	7	3	109
Ajidahun 2017	114	18	11	16	—	—	—	52	R 40/L 46	51	LH 38/RH 24	R 15/L 15	47	—	—	—	373
Ling 2018	192	—	—	—	—	—	—	33	36	—	44	34	22	—	1	—	170
Total cases	273	74	107	3	122	1	772	1299	519	1909	993	1134	61	78	1368	8939	
%	5	1	2	0.1	2	0.02	15	25	10	37	19	22	1	2	27		

Table 4. Prevalence of musculoskeletal injuries among musicians.

Chief Complaints	participants	Soreness	Pain	Blisters	Cramps	Bruise	Tightness	Fatigue	Tension	Tendonitis	Joint pain	Numbness	tingling	Total cases
Buckley 2006	111	-	-	-	-	-	-	3	1	2	5	15	1	27
Moffit 2015	154	108	37	5	-	3	2	-	-	-	-	-	-	155

Table 5. Epidemiological studies with reported chief complaints.

Performing Arts Medicine

A review examined the comparison between professional athletes and the performing arts. Some similarities included performing or playing late into the evening and having a schedule with 150 games/performances a season.[28] Both groups can also experience altered sleeping and eating habits, which can factor into an environment that can promote injury. There has been a concerted effort to improve the availability of preventative medicine within the performing arts. Similarly, professional athletes and performing artists use their physical capabilities to perform at high levels. Therefore, emphasizing the need to incorporate a multi-faceted healthcare model for the performing arts.

A review was completed examining patterns of illness affecting performing artists. In this retrospective review, performing artists included dancers, singers, actors, and instrumental musicians.[1] MSK injuries within the performing arts usually stem from artists beginning their profession at an early age. One example is ballet dancers going to classes when they are young children to develop the strength and precision needed to look graceful on the dance floor. To demonstrate the prevalence of injury in the arts, a survey was conducted which stated that, among American orchestral musicians, 82% experienced medical problems, with 76% reporting at least one MSK injury complaint severe enough to affect their performance.[1] Ostwald et al. [1] found that 97% of participating dancers reported serious injury over eight months. We know that performers experience a high prevalence of injury throughout their careers. This retrospective review will cover performing artists within the college and university setting.

Another review by Hansen et al.[29] examined common MSK injuries unique to musicians and dancers. Researchers point out that treatment within this patient population requires understanding that these injuries occur within a distinctive lifestyle. A performing

artist's lifestyle has extreme physical and emotional stressors, and treating the artist requires a specialized team approach that appreciates the unique lifestyle outside the range of traditional competition.[29]

Dancers

Dancing puts great stress on the body due to the multitude hours spent doing repetitive movements on a hard-surfaced floor. This review predominantly explores MSK injury in ballet dancers with a quick mention of alternative dancing forms. MSK injuries are seen as the most frequent medical problems among classical and modern dancers. A questionnaire intake review by Kenny et al. [47] stated that 97% of all dancers surveyed for their review had sustained some kind of injury over an eight-month period.[1] This retrospective review will also report common injuries within the dance profession.

Dancers suffer from various lower extremity injuries of the hip, knee, ankle, or foot, etc. With dance being intensely movement-based, any lower extremity injury may be severe or even career-ending. A lateral ankle sprain is a common injury for dancers and may lead to ankle instability and possible re-injury. Ankle sprains may result in a dancer developing chronic ankle instability (CAI). CAI is described as repeated bouts of ankle pathology that result in recurring ankle injuries.[24] Simon J et al. [24] identified the prevalence of CAI and related symptoms of ankle sprain in a student dance population. Participants were taking part in the modern or ballet dance major at the involved university. The investigators collected the results using functional ankle instability survey identification, which helped identify CAI's presence. Of the 100 participants in the study, 83 questionnaires and surveys were collected in total. The study excluded dancers with a current injury, but 54 of the 77 dancers remaining reported previously

having an ankle sprain, and 41 of the 54 dancers included in the study reported CAI characteristics. [24](Table 3)

It is common for ballet dancers to be en pointe during a routine. This dancing technique requires dancers to be up on their toes for extended periods. That is considered an open-packed position and offers minimal ligament support.[24] In the open-packed position, the ankle is in full plantar flexion, leaving it in a very vulnerable position, and predisposing the dancer to injury. Another factor may be a dancer who has pes cavus feet or a high arch. Having higher arch increases stress on the lateral structures of the ankles. A limitation of the study is the small sample size, especially when broken down into two groups. Findings showed 53% of study participants had CAI, and ballet dancers had a higher probability of having bilateral CAI.[24]

A systematic review by Trentacosta et al. [27] investigated the prevalence of lower extremity injuries among a wide variety of ballet dancers with varied experiences. Of the studies included in the systematic review, 2,001 dancers were included in the study, and a total of 3,527 MSK injuries were seen in 1,553 dancers.[27] The systematic review focused on hip and groin injuries resulting in 345 injuries reported (Table 3). The research used for this systematic review spanned a timeline of 15 years and included seven countries. This demonstrates a marked prevalence of MSK injuries within the performing arts across all levels of expertise. Costa et al. [25] similarly investigated the prevalence of MSK injury in professional and non-professional ballet dancers. From the 110 questionnaires answered by the participants there was a total of 144 reported injuries. Of those injuries, one-third of them were reported as ankle sprains, which resulted in 50 of the 144 injuries (Table 3). This accounted for 69.8% of injuries in the professional dancers and 42.1% in non-professional dancers.[25]

Pellicciari et al. [26] employed a questionnaire survey to record injuries among Italian DanceSport athletes. DanceSport consists of common competition styles such as the waltz, tango, slow foxtrot, quickstep, samba, rumba, jive, and more. The authors explored the prevalence of MSK injuries, their location, and the nature of the trauma to establish better prevention measures that help keep dancers and performers healthy.[26] Of the 102 participants who filled out the form, 74 reported having a lower extremity injury within the past year.[26](Table 3) Another Survey by Rothenberger et al. [22] investigated the prevalence of injuries among aerobic dancers. This form of dance is lead by instructors in a class format for 50 to 60 minutes. As described by Rothenberger et al., the authors reported a large majority of the reported injuries involved lower back (158) and lower extremity (380) regions of the body.[22] Of the 726 aerobic dancers, there were a total of 1,230 injuries reported over a week (Table 3).

Ambegaonkar JP et al. [30] documented the prevalence of prior anterior cruciate ligament (ACL) injuries among collegiate dancers. ACL injuries occur most frequently during a plant-and-cut motion of the lower extremity.[30] The study states that no extensive work has been published addressing ACL injury rates in female dancers. The study implemented a retrospective cross-sectional injury surveillance design. Participants included 145 female dance students with 12.3 ± 5.7 years of dance experience.[30] Results were collected using a standard health history questionnaire. If anyone noted that they had experienced an ACL injury, detailed information concerning the injury was collected from that participant. Of the 145 participants, only two reported having a previous ACL injury. Both instances happened outside of dance and were diagnosed as first-degree sprains. Neither injury required surgical intervention.

Ambegaonkar et al. [30] hypothesized that one reason for ACL injuries not being as common in dance is that dancers may co-contract antagonistic muscle groups.[30] Unlike

conventional athletics that rely on more reactive movements, dancers need to maintain a smooth aesthetic to their performance to appeal to a judge or the public's eye. The study claims that more research is needed to support this hypothesis. Another factor that may reduce the risk for ACL injury in dancers is their postural balance throughout dynamic movements. A limitation to the study includes participants' ability to recall past injuries and report information reliably.[30]

Due to the repetitive nature of the dance profession, it is common for dancers to suffer fractures. The types of fractures may include overuse or stress fractures, acute traumatic fractures, or an acute fracture in a chronic stress injury.[31]

Snapping hip syndrome (SHS) is another repetitive injury that may arise from overuse. SHS is seen in individuals who perform repetitive hip flexion, extension, abduction, or external rotation.[32] SHS most commonly presents itself as the Iliotibial (IT) band becoming inflamed and beginning to snap over a bony surface such as the femur/hip's greater trochanter. If ignored, it may produce muscular weakness and a reduced range of motion from increasing pain. For a performer like a dancer, if this condition develops to become severe, it may immobilize them and keep them from performing. Nolton et al. [32] stated that the incidence of hip injuries in dancers is 0.97-1.24 injuries/1,000 dancer hours, and most of those injuries are in female amateur dancers.[32] A previous study stated that 14% of all dancer injuries are reported at the hip. This problem is mostly due to the repetitive nature of dance movements such as grand pli  , pass   d  velopp  , etc.[32] Many of these movements expose the hip to a vulnerable, externally rotated position.

Instructors and health professionals need to implement preventative measures to address SHS issues before they can cause any complications. Examples could include conservative stretching protocols to relieve muscular tension.[32] Other measures could be implementing

screening protocols to determine whether dancers are actively dealing with SHS or any muscular discrepancies.

A study conducted by Zikan et al [33] examined the relationship between joint mobility and the presence of injury and pain among ballet students in Brazil. Hypermobility was defined as the ability to have the broadest range of joint movement, allowing a more comprehensive range and variety of movements.[33] This study focused its search on vocational schools for classical ballet in Brazil. Investigators used the Carter and Wilkinson's Joint Mobility Scale to measure joint mobility. They then investigated whether the individuals within the hypermobile group experienced injuries more frequently. To be considered hypermobile, participants would have to score at least a four out of nine, with nine being the maximum score on the scale.[33] Of the 100 participants in the study, 83% had a score of four or higher and were classified as hypermobile. Among these individuals, it was stated that 78.3% had injuries, versus 88.2% of the non-hypermobile individuals having injuries. There was no statistical significance between the two groups ($p = 0.351$).[33]

When they considered lesion characteristics like sprains (24%), tendinitis (17.6%), and fractures (14.4%), 88.5% of these values originated from the hypermobile group of ballet dancers.[33] This study showed that hypermobility is a risk factor for lesion-type injuries and can increase the risk of injury.

Belly dancing is not a common dancing style that is studied. Milner SC et al [34] put together a descriptive study whose primary purpose was to examine the most common injury sites and identify potential factors associated with injury risk within the belly dancing community. Results were collected using an online survey or paper-based questionnaire. One hundred and nine questionnaires were collected. Participants had a mean age of 44.3 years and

danced a median of 3 hours per week. The injury rate was 37% of the 109 participants.[34]
Common injuries were reported to the lower limbs, and the trunk.

Instrumental Musicians

Instrumental musicians, predominantly stringed instrumentalists, are at great risk for performance-related musculoskeletal disorders (PRMD). These mimic similar characteristics of injuries to dancers and can be caused by repetitive actions during practices or performances.[35] An article by Hoppmann et al. [36] stated that there are three major classes of performance-related problems. One concern is MSK overuse ($\geq 50\%$), the second is nerve entrapment and thoracic outlet syndrome (20%), and third is focal dystonia (10%).[36] Other injuries and ailments stem from factors such as hypermobility, osteoarthritis, fibromyalgia, and acute trauma.[36]

Musicians who play stringed instruments are affected more by MSK injuries than other instrument groups.[20] Ajidahun et al. [20] produced a cross-sectional study designed to examine risk factors for MSK injuries among string instruments. The study included 114 string instrumentalists, with 86 (77%) reporting to be experiencing problems; 39 (35%) members of that subgroup suffered injuries that had affected some aspect of their performance.[20, 36](Table 2) The most commonly injured regions of the body for string instrumentalists are the shoulders and trunk. Common symptoms for this pain included aching, soreness, tingling, and fatigue, which was the most common of the lot.

Another fast-growing group of musicians who experience MSK injuries and problems includes guitarists. A cross-sectional study done by Winklund and Chesky [10] investigated self-reported problems among guitarists between different types of guitars. This study specifically addressed acoustic guitar, electric guitar, electric bass, and banjo players. Instrumental musicians

can commonly play a wide variety of musical instruments and gain that experience to open careers in both performing and educating. As displayed in Table 1, the highest site-specific injuries included the left fingers, left wrist, and left hand.[10] The cross-sectional study reported 1,783 MSK injuries among the participants of each study had within the data analysis. Of those 1,783 injuries, 787 of them were located among the hands, wrists, and fingers (Table 4).

A descriptive study by Ackermann et al [14] reported on the findings collected from a survey of musicians in professional symphonic and pit orchestras in Australia. This questionnaire focused on the presence of PRMD within this sampled group (Table 4). The questionnaire was a self-reported study, and only around 70% (n = 377) of the orchestral population filled out the questionnaire. Of the participants in the survey, 84% have experienced pain or injuries that prevented them from playing their instrument or participating in rehearsals or performances to the best of their ability.[20] Like athletics, the orchestras in Australia are highly competitive and require current and future members to be both physically and psychologically sound. A similar, self-reported survey study by Lonsdale et al. [19] investigated playing-related health problems among instrumental music students at a university in Malaysia (Table 4). Results from the survey shared that 46.4% of the respondents had experienced playing-related pain at some point while at the university, and 36.8% reported that the level of pain or discomfort had some impact on their ability to play their instrument for extended periods.[19]

Brusky P. conducted a questionnaire survey that investigated the prevalence of injury among female bassoonists. Similarly, the data collected from this survey remarked on the fact that the most common PRMDs were located among the upper extremities of the bassoonists, as displayed in Table 2.[12] Another group impacted by PRMDs is pianists. A survey conducted by Ling et al. [21] investigated classical piano students in Malaysian tertiary institutions. Some

factors that contribute to these PRMDs include faulty piano techniques.[21, 37] Some examples of faulty techniques include pressing too hard on the keyboard, head misaligned from a central position, elevated shoulders, a locked or curving wrist, and raised forearms.[21] Another retrospective study investigated the prevalence of PRMDs of the upper extremity and trunk among Japanese pianists and piano students.[9] Results from distributed surveys showed that 77% of the respondents had some form of PRMDs on some part of their body.[9] Common musculoskeletal injury sites on the body for this performing group include the hands, fingers, wrist, forearm, elbow, shoulders, neck, and trunk.[7, 21](Table 4)

It would be advantageous to provide health services to the younger population of aspiring music students to give them the best possible chance of joining prestigious groups like a professional orchestral group in Australia and many groups just like it worldwide.

Collegiate Marching Band and Color Guard

Injuries in marching band can be unexpected due to the involvement of marching, playing an instrument, and handling a piece of equipment all at once.[2, 3, 17] A study by Beckett S et al. [17] reported the prevalence of musculoskeletal injuries (MSI) within marching band and color guard (Table 4). They reached out to 102 collegiate marching band programs and sent out a health status survey for their band members to answer if they wished. They had a total of 1,379 respondents, and 25% of those individuals stated that they had sustained a MSK injury while participating in marching band activities.[17] Throughout their marching season, the body region that was affected the most was the lower extremities. Among the instrumentalists, 58.5% had an injury to a lower extremity; 33.8% had sustained a lower extremity injury within the color guard.[17] The study noted that the most reported injury suffered during the season is ankle sprains, and that has to do with the repetitive marching and, in some cases, the surfaces that they

practice and perform on. Regarding time missed from injury, the respondents averaged 9.46 ± 27.60 hours missed from practice or performances.[17]

These trends may also be dependent on the university that the individual attends. Each program is different, and some will require higher standards and rigorous training to perform during game day. MSI seem to be prevalent because of the pre-existing physical training level of the participants. Students enter college and are not prepared for the workload because they have never marched before. A limitation for this study is the matter of the band members self-reporting their injuries which could lead to an inconsistency in answers on the survey.

A descriptive retrospective study reported the MSK injury experienced during summer band camp by high school marching bands.[2] This study reported on the marching band camps clinic logs for a total of two summers. During camp, each band member marched an average of seven hours a day with two hours of sectionals in the evening. Patients' chief complaints were categorized as follows: lower extremity musculoskeletal injuries, skin problems, gastrointestinal distress, heat distress, blisters, upper extremity MSK injuries, and other illnesses.

Musical Theater Students

Musical theater students are multitalented and expected to excel in dancing, singing, and acting. Musical theater is versatile because every show demands a different amount of effort and attention to execute it. Physically, the risk of MSK injury increases as the dance demands of the show increase. Wanke et al. [23] worked on a pilot study that surveyed musical theater students' health problems. They targeted one university and provided a questionnaire survey to all students in the theater department. The study had a total of 37 participants, and 45.9% of them claimed to have an injury twice a year, with 29.7% of that subgroup reporting three to four injuries.[23] Chronic complaints of injury were mostly directed at the lumbar vertebrae. For time out from

activity, it was found that 14% were absent for 1-3 days, 17% for 4-10 days, and 21% for longer than 10 days.[23] In conclusion, it is important to establish preventative measures that promote healthy performers who are prepared for the rigors of the performance.

Conclusion

The purpose of this review was to examine the prevalence of musculoskeletal injuries within the performing arts at Marshall University. The categories reviewed were dance, instrumental musicians, marching band, color guard, and musical theater. All of these activities require an extensive period to practice and rehearse before performing in front of a judge or audience.[1, 28, 29, 35] Due to the visual demand, performers need to perform at peak levels and maintain an aesthetic that traditional athletics can give up for functionality. Playing a musical instrument at a high level of competency requires complex motor skills. As mentioned earlier in this report, the high-intensity of training, practices, and performances makes PRMDs common among the performing arts.[38] Injuries to the lower extremities frequently occur in activities such as dancing and marching band. Activities such as playing an instrument and performing in musical theater can vary because of the creative nature of the professions. It is important as health professionals to establish preventative treatment measures to address anyone predisposed to injury and understand that the performing arts are filled with ailments that require medical intervention to ensure performers can continue their craft.

Healthcare providers and sports medicine professionals spend a large amount of time and resources monitoring athletes and the demands required for their targeted sports. On the other side of the equation, musicians have had minimal interaction with specialized performing arts healthcare professionals.[38] This literature review is designed to help determine if the data being collected from Marshall University is similar to what is being reported for professional

performers. Are there any similarities or differences when addressing musculoskeletal disorders across a wide spectrum of performing artists? This review will help support that providing medical services to a younger performing artist will help decrease overuse injuries as people progress into the later stages of their careers.

CHAPTER 3

METHODS

This study is a retrospective study investigating musculoskeletal injuries for the Center for Wellness in the Arts at Marshall University. For this study, the examiners used Core-AT, an electronic medical record (EMR) program that stores statistical data regarding patient MSK injuries and ailments. The examiners are also reviewing data collected and stored using Microsoft Excel. The goal is to identify factors such as frequency of injury, region of the body affected, the cost associated with treatment, performing groups of participants, whether there is a correlation between instruments played and injuries, and how these factors compare to the data collected Marshall University.

Participants

This retrospective review of data investigates theater, marching band, color guard, and music majors. All participants participate in performances put on by the University, whether a concert, competition, or theater production. All the data collected was from the previous six years and has been categorized. The data extracted has been drawn from the documentation database with participants that had been previously listed. Enrollment numbers include both graduate and undergraduate students at Marshall University. Beginning in the fall of 2014 and going until the spring of 2020, a possible total of 854 combined graduate and undergraduate music majors and 205 undergraduate theater majors have had access to Athletic Training services. Injury trends were drawn from that data. Participants included in the study were diagnosed with an MSK injury throughout their time at Marshall University. All participants were diagnosed by a certified Athletic Trainer (AT) employed as a graduate assistant working towards a master's degree.[39] There was a total of six athletic trainers over the six years of data collected.

Institutional Review Board Approval

The Institutional Review Board reviewed the study and determined that it was exempt due to the fact that no consent was required from participants to perform the study.

Design and Setting

The current study is a retrospective chart review of de-identified patient data compiled via a web-based EMR system. The CORE-AT EMR was managed through the Athletic Training Practice-Based Research Network (AT-PBRN) and housed at A.T. Still University. The AT-PBRN is an Agency for Healthcare Research and Quality-affiliated, practice-based research network [46] whose standards and procedures for utilizing EMR data for research purposes have been previously defined and used for publication.[39, 40] Onset and completion of organized performing arts activities were dependent upon the University's academic calendars. The performing artists had access to a certified Athletic Trainer (AT) during organized rehearsals and performances. The CWA athletic trainers covered both rehearsals and performances for theater students, marching band, and music majors. In addition, these students had access to additional athletic training/medical care during either scheduled, or as-needed, clinical appointments.

Data Entry

The CWA Athletic Trainers have entered and stored performing artist MSK injury records in two EMRs. From 2014 to 2018, CWA medical records were stored in an Excel-based medical record created by the CWA. From 2018 to the present, the CWA stored medical records in the CORE-AT EMR. Before being granted permission to use the EMR, ATs complete a two-hour training session on using the EMR to ensure data quality.[39] Following the training session, ATs were able to use the EMR to document all aspects of routine patient care, including injury summary reports, daily treatment, discharge summaries, and economical estimate reports.

Patients also fill out forms that provide outcome measurements to show their injury status progression over a length of time. Core-AT provides the health care provider with baseline values for the early stages of injury, and can help support decisions to continue with effective treatment or review the direction of a treatment plan. Investigating injury summary reports, we have collected data such as patient gender, the previous and current status of reported injuries, the discipline the patient participates in, and the treatment provided by an AT at Marshall University. All data entry has been recorded by graduate assistants working for the CWA at Marshall University. Every graduate assistant who has worked for the CWA is a Certified Athletic Trainer who was hired to work solely with the performing arts.

Instrumentation

The CORE-AT EMR (www.core-at.com) is a web-based, HIPAA-compliant patient documentation system that has been described in detail in previous studies.[46] A Certification of Honest Broker System/Processes provided by the EMR developer (Ripple Group, Calgary, AB, Canada) ensures that patient data obtained by the AT-PBRN is de-identified following federal regulations and guidelines. Before the 2017-2018 academic year, the EMR was modified to include performance-specific classifications, mechanisms of injury, activities, and fitness assessments unique to this setting in consultation with the research databases used in conjunction with this study. The current study reviewed data from the demographic injury from within the EMR. For quality assurance purposes, patient data is collected as structured variables (i.e., drop-down menus, radio buttons) within the EMR. Before Marshall University implemented Core-AT for documentation and data collection, all records were stored in Excel spreadsheets developed internally.

The AT-PBRN team aims to engage clinicians with a shared vision to enhance patient care through a community of practice and peer learning.[46] Another aim of the AT-PBRN is to generate, disseminate, and implement practice-based evidence to inform patient care decisions and improve healthcare outcomes.[46]

Limitations

Over the course of the six years the program has been running, multiple Athletic Trainers have entered data into the EMR database, which caused varying data. On some occasions, patients who initially sought treatment by an Athletic Trainer would not follow up for further treatment or evaluation. If no follow-up was established, patients would then be discharged from the system. Data was only documented during periods when school was in session, so documentation would have times of inactivity during scheduled university breaks.

Delimitations

This program included college-academic-level performing artists and it may be different if we were to correlate this data to professional or younger performers. Students in college or university fall within a range of 18–23 years of age.

Statistical Analysis

The injury prevalence rate was calculated from the published literature by dividing the injury occurrence by the number of participants provided by the published paper. The CWA injury prevalence was calculated by dividing the number of injuries by anatomic region by the total number of patients seen by the CWA and by the total number of students in the Marshall School of Music and Theatre. Statistical analysis was performed with SPSS 24.0 (SPSS, Chicago, IL). A 2x2 Pearson Chi-Square test was performed to test for differences between the injury prevalence from published literature and the CWA injury prevalence.

CHAPTER 4

RESULTS

Enrollment numbers for the theatre department included students participating in Marshall's musical theatre, production, or theatre performance programs. The music department has students enrolled in both music performance and music education. Over the six years, a total of 1,059 students (854 musicians/205 theatre) enrolled at Marshall University within their respective domains who had access to the services provided by the CWA. From the start of the fall 2014 semester up to the 2020 school year, the CWA had a total of 1,633 contacts with patients. These contacts included multiple visits by individual patients for treatments, evaluations, discharges, and injury demographics. The patient contacts represent the overarching need for preventative medicine intervention for performing artists of collegiate age in a university setting. Table 6 depicts the total number of injuries per anatomical region reported within the CWA. The table is divided into school years to show the general distribution of student enrollment since the founding of the CWA. The students included in the total enrollment population incorporated music education and music performance majors within the music department.

Total																	
School Year	participants	knee	ankle	hip	calf	foot	thigh	lumbar spine	shoulder	thoracic spine	hand/wrist/fingers	upper arm/ elbow	head/neck	Upper extremity	Lower Extremity	Other	Total cases
2014 - 2015	200	7	4	2	1	3	0	11	6	5	16	5	13	4	2	2	81
2015 - 2016	199	4	7	0	0	0	2	7	2	2	2	2	6	8	0	0	42
2016 - 2017	179	2	4	2	1	0	1	3	5	0	6	0	1	0	0	0	25
2017 - 2018	175	2	1	2	0	3	1	3	8	0	1	1	4	0	0	1	27
2018 - 2019	143	4	2	4	0	0	1	1	5	0	2	2	1	0	0	0	22
2019 - 2020	163	6	7	7	0	1	2	7	13	0	4	5	0	1	2	0	55
	Total cases	25	25	17	2	7	7	32	39	7	31	15	25	13	4	3	252
	CWA %	2.4	2.4	1.6	0.19	0.66	0.66	3	3.7	0.66	2.9	1.4	2.4	1.2	0.4	0.3	23.8
	Published Lit.	5	4	2	1.2	3	0.7	12	17	7	23	12	14	0.8	11	17	

Table 6. Prevalence of musculoskeletal injuries within

A Chi-Squared test was performed to assess the similarities and differences of injury prevalence between the CWA and the published literature. The reported p-value for each anatomical region will show whether there is a statistical difference between our expected data with the published literature, and the observed data reported by the CWA. The CWA reported less than expected injuries to the knee ($\chi^2 = 21.969$, $p < 0.001$), ankle ($\chi^2 = 12.931$, $p = 0.003$), calf ($\chi^2 = 11.253$, $p = 0.007$), foot ($\chi^2 = 22.039$, $p < 0.001$), lumbar spine ($\chi^2 = 30.613$, $p < 0.001$), shoulder ($\chi^2 = 42.726$, $p < 0.001$), thoracic spine ($\chi^2 = 5.045$, $p = 0.024$), hand/wrist/and finger ($\chi^2 = 55.181$, $p < 0.001$), upper arm/elbow/and forearm ($\chi^2 = 47.292$, $p < 0.001$), head and neck ($\chi^2 = 35.011$, $p < 0.001$), lower extremity ($\chi^2 = 181.967$, $p < 0.001$), and illnesses or ailments categorized as “other” ($\chi^2 = 7.506$, $p < 0.001$). Data reported with a p-value greater than 0.05 tells us that there is not any statistical difference between injury prevalence of the CWA data compared to the published literature. The CWA reported a greater prevalence of injuries to the hip ($\chi^2 = 2.274$, $p = 0.131$), thigh ($\chi^2 = 0.257$, $p = 0.611$), and upper extremities ($\chi^2 = 0.043$, $p = 0.835$) compared to the reported literature.

Musicians																	
School Year	participants	knee	ankle	hip	calf	foot	thigh	lumbar spine	shoulder	thoracic spine	hand/wrist/fingers	upper arm/ elbow	head/neck	Upper extremity	Lower Extremity	Other	Total cases
2014 - 2015	173	6	2	2	1	2	0	4	4	3	15	5	5	2	2	1	54
2015 - 2016	168	4	6	0	0	0	2	5	1	1	0	1	3	4	0	0	27
2016 - 2017	139	2	4	2	1	0	1	0	4	0	6	0	1	0	0	0	21
2017 - 2018	134	1	1	1	0	0	0	0	4	0	1	1	1	0	0	1	11
2018 - 2019	114	1	2	2	0	0	0	1	2	0	2	2	1	0	0	0	13
2019 - 2020	126	4	5	4	0	0	2	5	12	0	4	5	0	1	1	0	43
Total cases	18	20	11	2	2	2	5	15	27	4	28	14	11	7	3	2	169
CWA %	2.1	2.3	1.3	0.2	0.2	0.2	0.6	1.8	3.2	0.5	3.3	1.6	1.3	0.8	0.4	0.2	20
Published Lit.	5	1	2	0.06	2	0.02	15	25	10	37	19	22	1	2	27		

Table 7. Prevalence of musculoskeletal injuries among musicians at Marshall University.

Table 7 covers the total number of injuries per anatomical region within the music department at Marshall University. The CWA reported less than expected injuries to the knee ($\chi^2 = 28.819$, $p < 0.001$), hip ($\chi^2 = 4.507$, $p = 0.033$), calf ($\chi^2 = 5.05$, $p = 0.02$), foot ($\chi^2 = 24.25$, $p < 0.001$), lumbar spine ($\chi^2 = 45.231$, $p < 0.001$), shoulder ($\chi^2 = 97.097$, $p < 0.001$), thoracic spine ($\chi^2 = 9.39$, $p = 0.002$), hand/wrist/and finger ($\chi^2 = 15.285$, $p < 0.001$), head and neck ($\chi^2 = 81.241$, $p < 0.001$), upper extremity ($\chi^2 = 6.809$, $p = 0.009$), lower extremity ($\chi^2 = 53.125$, $p < 0.001$), and illnesses or ailments categorized as “other” among musicians compared to the reported literature ($\chi^2 = 221.973$, $p < 0.001$). The CWA reported a greater prevalence of injuries to the ankle ($\chi^2 = 2.105$, $p = 0.146$), thigh ($\chi^2 = 1.482$, $p = 0.223$), and upperarm/elbow/and forearm injuries ($\chi^2 = 2.283$, $p = 0.131$) among musicians compared to the reported literature.

Theatre/Dance																	
School Year	participants	knee	ankle	hip	calf	foot	thigh	lumbar spine	shoulder	thoracic spine	hand/wrist/fingers	upper arm/ elbow	head/neck	Upper extremity	Lower Extremity	Other	Total cases
2014 - 2015	27	1	2	0	0	1	0	7	2	2	1	0	8	2	0	1	27
2015 - 2016	31	0	1	0	0	0	0	2	1	1	0	1	3	4	0	0	13
2016 - 2017	40	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	4
2017 - 2018	41	1	0	1	0	3	1	3	4	0	0	0	3	0	0	0	16
2018 - 2019	29	3	0	2	0	0	1	0	3	0	0	0	0	0	0	0	9
2019 - 2020	37	2	2	3	0	1	0	2	1	0	0	0	0	0	1	0	12
	Total cases	7	5	6	0	5	2	17	12	3	1	1	14	6	1	1	81
	CWA %	3.4	2.4	2.9	0	2.4	1	8.3	5.9	1.5	0.5	0.5	6.8	2.9	0.5	0.5	40
	Published Lit.	5	9	2	3	3	2	7	3	1	1	0.7	2	0.3	26	0.6	

Table 8. Prevalence of musculoskeletal injuries among theatre performers at Marshall University.

Table 8 displays the total number of injuries for a variety of anatomical regions among theatre and dance performers within the CWA. The CWA reported a greater prevalence of injuries to the knee ($\chi^2 = 0.561$, $p = 0.453$), hip ($\chi^2 = 0.681$, $p = 0.409$), foot ($\chi^2 = 0.298$, $p = 0.585$), thigh ($\chi^2 = 0.939$, $p = 0.332$), lumbar spine ($\chi^2 = 0.618$, $p = 0.431$), thoracic spine ($\chi^2 = 0.248$, $p = 0.617$), hand/wrist/and finger ($\chi^2 = 0.706$, $p = 0.401$), and upperarm/forearm/and elbow injuries ($\chi^2 = 0.543$, $p = 0.461$) among theatre and dance performers compared to the reported literature. The CWA reported less than expected injuries to the ankle ($\chi^2 = 9.682$, $p = 0.001$), shoulder ($\chi^2 = 8.56$, $p < 0.001$), head and neck ($\chi^2 = 22.301$, $p < 0.001$), upper extremity ($\chi^2 = 24.268$, $p < 0.001$), lower extremity ($\chi^2 = 71.215$, $p < 0.001$), and illnesses or ailments categorized as other among theatre and dance performers compared to the reported literature ($\chi^2 = 11.043$, $p < 0.001$). The CWA also reported no calf injuries over the course of data collection for the theatre department.

CHAPTER 5

Discussion

This epidemiological study aimed to investigate the prevalence of MSK injuries reported in the published literature compared to the CWA at Marshall University. The investigators performed an epidemiological review of the published literature to determine if the injuries sustained within the CWA are similar in frequency to professional performing artists or artists outside of collegiate age. The investigation focused directly on performing artists, including marching band, color guard, music majors, theatre, and dance performers. After investigators reviewed the collected data from the CWA EMR, the CWA reported a lower prevalence of injury in most of the listed anatomical regions in each table than the published literature. The alternative hypothesis was that the CWA would report a lower prevalence of MSK injuries compared to the published literature. The alternative hypothesis has been supported in part with the lower injury prevalence within the CWA.

A variable impacting the results for either the CWA or non-CWA reported values was the difference in age of the participants within the reported literature and the CWA. A majority of the performers who sought services from the CWA were college-age students. The age range of students participating within the theatre department was 19 – 21 years of age. Similarly, the age range for undergraduate students within the music department ranged 18 – 25 years of age, with an average of 20 years. A noticeable difference is that the music department has graduate students with an age range of 23 – 60 years of age, with an average of 31 years. The graduate student positions allow individuals to return to school to seek continued education, resulting in a wide variability of ages when looking at the performing arts community at Marshall University. Even though Marshall offers these graduate student positions, there are not many graduate students compared to the occupancy of professional orchestras. A cross-sectional survey by

Ackermann et al. [14] included 377 participants, in which seven of them were between the age of 15-24 years. The rest of the 370 participants ranged from 25–69 years. The age range of musicians in the published literature can fall within the collegiate age range investigated for this review. However, most professional musicians were older than the typical 18-22 years of age for undergraduate music students. A cohort study by Bronner et al. [41] investigated two professional dance companies over 15 years. The age range for the two companies was 21-51 and 18-26 years of age. Performers around collegiate age are in the earlier stages of their career. They can develop detrimental habits that can cause overuse injuries as they progress further in their career as a performer or educator [1, 5]; with the increased years of performing experience marked by the older performing artists, the potential for injury increases.

The lack of medical knowledge of injuries and the availability of CWA services for these performers may be an important factor to consider when addressing injury prevalence. As this epidemiological review investigated MSK injuries within the performing arts, the injuries reported within the CWA mainly were classified as an overuse syndrome. Overuse syndrome can be a broad description of a collection of symptoms of pain tied to the performer's activity. The most common symptom of overuse syndrome is pain, which is the most prevalent medical problem affecting performing artists.[29] Some examples of injuries that fall into this category include muscle strains, ligament sprains, tendinopathies, and injuries acute and chronic.

There is variability in injury location when looking at each performing group. Tables 7 and 8 reveal that musicians showed a higher number of reported injuries to the knee, hip, ankle, hand/wrist/fingers, and shoulders. In comparison, theatre performers showed a higher number of reported injuries to the lumbar spine, head, and neck. According to the reported literature, upper extremity injuries are most common among performers who play an instrument.[20, 42] Stage

actors and dancers see lower extremity injuries predominantly.[41, 43] Musicians at Marshall may have seen a greater occurrence of lower extremity injuries because of factors such as participating in marching band. Both lower and upper extremity injuries can present from repetitive marching and, if the instrument is large enough, the performer may be carrying a significant weight while marching.[3, 17] A large majority of students within the music department are required to participate in marching band as a class requirement. This requirement may result in participants who are not typically very active participating in a high-stepping, physically active marching routine.[2, 17] Regarding theatre, the demands of the performance may vary greatly from show to show. Some shows require being very active and mobile, while other shows may rely on dialogue and vocals.[23] With the variability of physical demands for theatre performers, the probability of injury fluctuates. The physical activity of the performing artist has an impact on the MSK injury rates reported.

Another factor predisposing performers to injury are extensive hours of practice or rehearsal. Students within the performing arts community at Marshall University have various performing responsibilities throughout their time at Marshall. Depending on the student's academic major and the classes associated with it, students are held accountable for attending individual lessons with instructors weekly. Students in the music department also participate in recitals and hearings that can greatly impact their progression forward for their major. With the importance of these performances, students greatly increase practice times and begin to pay less attention to important healthy habits like proper sleep, nutrition, and mental health.[23, 44] Additionally, university students are held accountable for maintaining the status of a full-time student, with some students taking a credit-hour load that exceeds the recommended amount of 15 credit hours.

There were some discrepancies looking at the number of students between the music and theatre departments. The music department had a mean of 142 students enrolled in an academic major offered through Marshall University each school year since the founding of the CWA. In contrast, the theatre department had 34 students enrolled through Marshall university in the same timeframe. With the greater number of musicians, there is a greater chance of finding someone with a musculoskeletal complaint. A discrepancy between the CWA data and the published literature is how the data or information was collected. Out of the 24 papers used to investigate the prevalence of MSK injuries outside of the CWA, 19 of them collected data using either a questionnaire or survey. The other five involved a study or scenario when the patient reported experiencing any pain or discomfort. Many of the questionnaires and surveys were sent through email to cover a wide range of performers. The data collected from the CWA is based on patients self-reporting injury experiences and seeking medical consultation from an Athletic Trainer. With a majority of the published literature data gathering being conducted through questionnaires, the results depend on the respondents' knowledge. In some cases, the respondents reported having more than one injury throughout a performing season. This resulted in studies performed by Steinmetz et al. [15] having a respondent population of 408 people and a total MSK injury case number of 2,219. Injuries reported within the CWA are self-reported by participants and are not entered into an EMR unless a certified medical professional has evaluated them.

This epidemiological review shows that there is a noticeable occurrence of MSK injuries within the performing arts industry. Marshall University is in a unique position because it provides a wide variety of services in an emerging field of medicine. This retrospective data review shows a need for preventative medicine within college-age performers to help prevent

acute or chronic injuries from progressing and hindering performers later in their careers. Athletic Trainers who worked for the CWA advertised their services to each department to explain to the performing artists at Marshall that they have access to healthcare services at little to no cost. Athletic Trainers introduced themselves at the beginning of each semester to bring awareness that they are available to the artists of either the theatre or music department. It was up to the performing artists to voluntarily seek out help from the athletic trainers. It also varied from clinician to clinician whether a patient should be entered into the EMR for an injury and/or follow-up appointments. Factors such as these had an impact on the data that was collected for the epidemiological review.

A cross-sectional study by Ranasinghe et al. [45] investigated work-related complaints of the neck, shoulder, and arm among computer office workers. A sample size of 2,210 office workers reported a prevalence of work-related complaints among these anatomical regions at 56.9%. When comparing this to performance-related injury prevalences, Wanke et al. [23] reported that 45.9% of the theatre students they investigated claimed to have sustained an orthopedic injury up to twice a year. Ackermann et al. [14] reported an 84% prevalence of pain or injury among orchestral musicians related to performance, and Ostwald et al. [1] reported an injury prevalence of 97% among dancers they had surveyed. These results further support the need for medical intervention within the performing arts community. Preventative medicine is an emerging field within the performing arts. The CWA is working to bring attention to the performing arts and do its best to educate performers on the importance of early preventative medicine.

Future Research

It would be beneficial to continue the investigation going forward within the CWA. Unfortunately, some of the potential data that could have been collected were hindered by the development of COVID-19. It would be beneficial to thoroughly investigate and incorporate more studies, including the prevalence of injuries among theatre performers.

Conclusion

The problem addressed by this study was whether MSK injuries are more prevalent among collegiate-age performing artists than those in previously-published literature. There was less of a prevalence of MSK injuries within the Marshall University's performing arts community. By providing early preventative medical interventions, clinicians and educators can better prepare young performing artists for the rigors of collegiate and professional spotlights.

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APPENDIX A. OFFICE OF RESEARCH INTEGRITY APPROVAL LETTER



Office of Research Integrity
Institutional Review Board
One John Marshall Drive
Huntington, WV 25755

FWA 00002704

IRB1 #00002205
IRB2 #00003206

March 31, 2021

Mark Timmons
School of Kinesiology, Marshall University

RE: IRBNet ID# 1740448-1
At: Marshall University Institutional Review Board #1 (Medical)

Dear Dr. Timmons:

Protocol Title: [1740448-1] Epidemiology of Musculoskeletal Injury in Performing Artists
Site Location: MU
Submission Type: New Project APPROVED
Review Type: Exempt Review

In accordance with 45CFR46.104(d)(4), the above study was granted Exempted approval today by the Marshall University Institutional Review Board #1 (Medical) Chair/Designee. No further submission (or closure) is required for an Exempt study unless there is an amendment to the study. All amendments must be submitted and approved by the IRB Chair/Designee.

If you have any questions, please contact the Marshall University Institutional Review Board #1 (Medical) Coordinator Margaret Hardy at (304) 696-6322 or hardyma@marshall.edu. Please include your study title and reference number in all correspondence with this office.

Sincerely,

A handwritten signature in blue ink that reads 'Bruce F. Day'.

Bruce F. Day, ThD, CIP
Director, Office of Research Integrity