Examining Collegiate Modern and Ballet Dancers’ Upper-Extremity Strength and Muscular Endurance: The Modified Push-Up Test

Author
Kanamoto, Vanessa Kalani

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Examining Collegiate Modern and Ballet Dancers’ Upper-Extremity Strength and Muscular
Endurance: The Modified Push-Up Test

THESIS

submitted in partial satisfaction of the requirements
for the degree of

MASTER OF FINE ARTS

in Dance

by

Vanessa Kalani Kanamoto

Thesis Committee:
Assistant Professor Dr. Kelli Sharp, Chair
Lecturer Diane Diefenderfer
Associate Professor Chad Michel Hall

2018
DEDICATION

To

my parents, brother, and fiancée.

I would not have made it this far without your love and guidance.
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ABSTRACT OF THE THESIS

Examining Collegiate Modern and Ballet Dancers’ Upper-Extremity Strength and Muscular Endurance: The Modified Push-Up Test

By

Vanessa Kanamoto

Master of Fine Arts in Dance

University of California, Irvine, 2018

Assistant Professor Dr. Kelli Sharp, Chair

Dance majors are expected to demonstrate proficiency in ballet and modern dance. It is shared belief that the physical demands vary between dance styles. As a result, site of injury may be determined by each genre (Ambegaonkar et al., 2012). Researchers have stated modern dancers have increased injuries to the upper-body, due to weight-bearing movements (Angioi et al., 2008). A sufficient amount of muscular strength and endurance is needed to withstand the load placed on the shoulder region. Fitness parameters such as strength and endurance influence the potential risk of injury (Ambegaonkar et al., 2012).

The purpose of this thesis was to investigate the upper-body strength and muscular endurance between collegiate modern and ballet dancers. The American College of Sports Medicine’s guidelines for the modified push-up test was used to assess these parameters (Riebe et al., 2016).

This study included thirty participants. The scores received by dancers were analyzed using the Mann-Whitney Test. The results concluded there was no significant difference between collegiate modern and ballet dancers’ upper-body strength and muscular endurance (p= 0.20). A probable explanation exists in the lack of supplemental training beyond technique classes.
The objective is to equip dancers with the knowledge that cross-training is needed to meet the physical demands of different dance genres. In addition, for educators to prepare their students to safely transition into other dance forms. In return, results obtained from this research may provide insight to increase dancers’ performance and reduce risk of injury.
INTRODUCTION

The highly physical and demanding activities required in dance puts dancers at risk for musculoskeletal injuries. Dancers participate in daily classes that can last up to 1.5 hours, in addition to extra time spent on rehearsals for performances (Miller, 2006). During this time, dancers are subjected to repetitive movement to master skills and performance qualities (Shah et al., 2012). This leaves the dancer exhausted and susceptible to injury. Annually, dance-related injury rates are reported to average between 67-95% (Fuhrmann et al., 2010). Due to the high percentage of injuries, professionals in the dance science field have made attempts to understand dance biomechanics to promote injury prevention in elite dancers. Despite the rising attention to dancers’ wellness, many studies have primarily focused on the injuries sustained by professional ballet dancers (Shah et al., 2012). Shah et al., 2012 and fellow researchers have stated the need for further study in modern dance in regards to injuries and their consequences (Shah et al., 2012).

The movement demands used in modern dance differ with respect to biomechanics in comparison to other dance styles (Weiss et al., 2008). For instance, modern dance incorporates dynamic movement patterns that require “extreme angular movements in which the upper-body, head and neck are regularly out of line with the lower body” (Ambegaonkar et al., 2012). This is noted by the dancers having to perform shoulder stands and inversions (handstands), which place them in weight-bearing positions with the load placed on the shoulder region. As a result, this puts a considerable amount of pressure on the shoulder musculoskeletal since these movements require strength and control to accomplish (Ambegaonkar et al., 2012; Weiss et al., 2008). The extreme weight-bearing positions used in modern dance poses a risk to the upper-body, most specifically the shoulder region. Kaiser et al., 2002 stated there was a higher rate of upper-
extremity injuries among collegiate modern dancers (Kaiser et al., 2002). These injuries included wrist sprains and strains, rotator-cuff strains, shoulder impingements, among other injuries (Kaiser et al., 2002).

Moita et al., 2017 have associated injuries with dancers exhibiting low levels of fitness, most specifically in regards to muscular strength (Moita et al., 2017). Dancers have perceived strength training as “diminishing aesthetic appearances and flexibility” (Moita et al., 2017). The lack of adequate fitness levels to meet the physical demands of dance is especially concerning for collegiate dance majors. Dance majors endure years of training taking 2-3 classes a day. The repetitiveness and excessive wear and tear of these daily activities leave the dancer in a vulnerable state (Thomas et al., 2009). In addition, the students are expected to be proficient in a variety of dance styles heightening their chances of injuries if they are not properly trained to undertake the specific demands needed for each dance style.

The purpose of this research is to examine the upper-body strength and muscular endurance of collegiate dance majors using The American College of Sports Medicine’s (ACSM) protocol for the modified push-up test to identify those at risk for injury. The intention of this thesis is to address the need to prepare dance majors to safely transition into a modern technique class, by informing educators in their role of helping students meet the physical demands of modern dance. In addition, to express to dancers the need to cross-train outside of their dance classes in order to meet the physical demands of different dance genres. The potential benefit of this thesis may bridge the gap between dance majors incorporating supplemental strength and endurance training into their everyday regimen, to withstand the repetitive movement needed to master a skill (Liederbach et al., 2013). By conditioning the body, the dancer is more physically capable to progress, and as a result, may decrease incidences of
Hypothesis

The hypothesis for this research is that collegiate modern dancers will exhibit higher scores for upper-extremity strength and muscular endurance compared to ballet dancers, because of the higher demands of performing weight-bearing activities. Although there is speculation of modern dancers receiving a higher score than ballet dancers, this study predicts the greater majority of modern dancers will be marked as “below average” based on the American College of Sports Medicine’s norm grading scale for the modified push-up test. The prediction for this outcome is due to the lack of supplemental upper-body weight training outside of technique classes (Angioi et al., 2009).
CHAPTER ONE:  
The Collegiate Dancer and Injuries

Collegiate dance majors often endure four to five years of rigorous training to progress in their dance techniques in order to pursue professional careers in the field of dance. The training these students undertake includes dance classes that can last up to 1.5 hours with a minimum of 2-3 classes a day (Miller, 2006). On average, technique classes are held 2-3 times throughout the week. This is a minimum of 6 hours a week dedicated to dancing and does not include hours spent on preparation for performances or outside dance activities. Rehearsals for dance productions can go up to 5 hours, with added time participating in performances. The dancer’s body can be subjected to highly physically demanding activity. This poses a problem as the typical dance major does not have sufficient amount of time to physically and mentally rest in between their hectic schedules (Miller, 2006). Due to this repetitive nature, dancers face the possibility of succumbing to overtraining syndrome, also known as “burnout” (Angioi et al., 2009).

Overtraining syndrome is characterized by an unexpected drop in performance that is not attributed to illness or injury (Liederbach et al., 2013). This occurs when performance or training loads are not matched with sufficient rest periods. This impacts the dancer’s cognitive and emotional well-being, such as experiencing low motivation (Liederbach et al., 2013). This leaves the dancer in a vulnerable state as they become susceptible to injuries. This is caused by the repetitiveness and excessive wear and tear of these daily activities with 60% to 75% resulting from overuse (Thomas et al., 2009). In dance literature, studies have reported injuries most often occurred during performance seasons when dancers were engaged in physical activity for approximately more than 4 hours (Liederbach et al., 2013). In addition, these studies also found
the highest incidence rate of dance injuries occurred during rehearsal periods when dancers learned new choreography and participation in repetition is at its highest (Liederbach et al., 2013). Liederbach et al., 2013 concludes injuries occur most when dancers are engaged in “training or work phases that entail overload and fatigue” (Liederbach et al., 2013).

This can be problematic for the dancer who continues to push themselves beyond their physical limits without considering the need for rest. Dancers are often unaware of the effects of overtraining and the lack of adequate rest, which can potentially lead to injury that can have lasting consequences, such as time away from technique class (Davenport et al., 2016). It is implied that the physical requirements of specific genres may determine injury location; therefore it is important to consider the demands for each style of dance to reduce the likelihood of injuries (Russell, 2013).

**The Differences between Modern Dance and Ballet**

In a conservatory-like college program (such as the University of California, Irvine), undergraduate dance majors are expected to take a variety of dance genres, such as ballet, modern, and jazz. They are also expected to successfully complete a certain level of competency within these styles of dance. This is problematic for dancers who may have little experience in modern dance, most specifically ballet dancers. A research study profiling the demographics and training characteristics of professional modern dancers stated 55% of females and 13% of males began their dance training with ballet (Weiss et al., 2008). Weiss et al., 2008 data also suggested ballet was the most accessible and favored dance genre by young girls, thus accounting for the higher percentages of females starting their training in ballet (Weiss et al., 2008). This is concerning for dancers who have primarily trained in ballet and transition to modern technique.
The biomechanical demands for ballet differ, in which it requires the dancer to primarily use the lower-extremity of the body. Researchers have stated foot and ankle injuries are the most prominent injuries ballet dancers experience (Angioi et al., 2009). This is caused by their extreme hypermobility to perform hip flexion, external rotation, knee flexion, and ankle plantar flexion (Ambegaonkar et al., 2012). Ambegaonkar et al., 2012 states that although ballet dance is “demanding of the lower back and leg musculature, these repetitive movements do not significantly engage the upper-body musculature” (Ambegaonkar et al., 2012).

In contrast, the physical demands of modern dance require musculature loads to the upper-body. Modern dance has evolved through the years, shifting the movement aesthetics towards athleticism. Athleticism is defined as the dancer’s ability to demonstrate physical strength, endurance, power, flexibility, or agility in order to successfully complete a given task (Wilmerding et. al., 2017). For instance, modern dance utilizes floor-work which consists of dynamic movement patterns integrating the ground and dancer. The demands of the dancer are usually to perform weight-bearing postures. The transition to successfully complete these tasks place extreme torque and pressure on the musculature of the body, specifically the shoulder joint since it demands strength and control to accomplish (Ambegaonkar et al., 2012; Weiss et al., 2008). Researchers have stated faulty alignment and improper biomechanics of the upper-body or lower-body are strong indicators of potential injury (Weiss et al., 2008). This poses a problem since it is implied modern dance frequently demands “extreme angular movements in which the upper-body, head, and neck are regularly out of line with the lower body” (Ambegaonkar et al., 2012). As a result of the increased physical load to the upper-body, the joints, muscles, and ligaments are put at potential risk for injury.
The Rise of Upper-Body Injuries

Studies have initially suggested that modern dancers frequently experienced injuries occurring in the low back and knee (Ambegaonkar et al., 2012). However, due to floor-based and partner maneuvers that require substantial weight-bearing involvement of the upper-extremities, the upper-body as a site for injury has increased from 3% to 14% (Angioi et al., 2008; Russell, 2013; Weigert et al., 2007). A research provided by Kaiser et al., 2002 stated there was a higher rate of upper-extremity injuries among collegiate modern dancers (Kaiser et al., 2002). These injuries included wrist sprains and strains, rotator-cuff strains, shoulder impingements, among other injuries (Kaiser et al., 2002). In addition, a paper discussing the etiology of injuries to the upper-extremity in the collegiate modern dance population allowing free access to healthcare services to students discovered a higher than expected report of 16.5% upper-body injuries demanding clinician sessions (Ambegaonkar et al., 2012).

Kinetic Chain

The American College of Sports Medicine (ACSM) refers to the kinetic chain as a concept to describe human movement introduced by Dr. Arthur Steindler (ACSM, 2012). The concept states there is an overlapping of segments that are connected by joints, which create a system of movement where a movement of one joint produces or affects movement at another joint within the kinetic link in a predictable manner (ACSM, 2012; Levangie et al., 2005). This concept is used in the analysis of human movement (ACSM, 2012). Dr. Steindler defined the chain as a “combination of several successively arranged joints constituting a complex motor unit” (ACSM, 2012). The series of movement that occurs within these segments are referred to as open and closed (ACSM, 2012). Levangie et al., 2005 describes open kinetic chain when “one
joint can move independently of others in the chain,” whereas “one end of the chain remains fixed” created a closed kinetic chain (Levangie et al., 2005).

An example of an open kinetic chain movement in dance is a grand battement. In this movement, one leg acts as the supporter and the foot is fixed on the ground. The opposing working leg is moving through the sagittal plane, as the hip is in flexion, the knee is in extension, and the ankle is plantar flexed. The moving leg is no longer fixed to the ground. An example of a closed kinetic chain movement in dance is a plié. The pelvis and lower limbs (knee flexion accompanied by hip flexion and ankle dorsiflexion) act as a closed kinetic chain while the upper-body is in an erect weight-bearing position with the feet fixed on the ground.

The kinetic chain acts as a ripple effect as one region of the body will influence a different area of the body. For instance, according to Clippinger, “the pelvis moves in relation to the spine, primarily by the lumbosacral joint, and relative to the femur at the hip joint” (Clippinger, 2007). Movements can be initiated from the spine, pelvis, or femur and can produce connected movement to at least one of the surrounding segments (Clippinger, 2007). For example, if the pelvis tilts anteriorly this would produce flexion in the hips, and in compensation, the lumbar spine would go into extension (Clippinger, 2007). Since the movement of the body is an interconnected system, for the purpose of this research the shoulder/thoracic complex will be further discussed.

**The Shoulder/Thoracic Complex and Implications**

The shoulder/thoracic complex is a complicated structure. It consists of the shoulder girdle, arm, forearm, and hand. These segments overlap with the thorax, and the lower lateral part of the neck (Houglum, 2010). In addition, there are muscles, joints, and ligaments that are necessary for stability, support, protection, and locomotion of the body.
The shoulder girdle consists of the clavicle and scapula. The joints that connect these bones are the acromioclavicular (AC) joint, glenohumeral joint and sternoclavicular joint. These joints determine the amount of mobility given at a certain area of the body. Some muscles that produce tension to generate movement associated with the shoulder girdle are the: serratus anterior, pectoralis minor, levator scapulae, rhomboids, and trapezius. The muscles and joints of the shoulder allow for a great range of motion. This allows the shoulder to perform different functions, such as flexion, extension, abduction, and adduction. Since there is limited stability provided by the bony articulation, ligaments, and capsule, this makes the shoulder vulnerable to injuries (Clippinger, 2007). Therefore, the shoulder and scapula muscles play an important role in maintaining the integrity of the shoulder.

Glenohumeral rhythm is the coordinated, linked, predictable movement between the scapula and humerus that aid with achieving a large range of motion of the arm, via the glenoid cavity (Houglum, 2010). The glenoid cavity is a shallow ball and socket joint that provides limited stability (Clippinger, 2007). The rotator cuff muscles (supraspinatus, infraspinatus, subscapularis, and teres minor) act as stabilizers for the shoulder joint by keeping the head of the humerus into the glenoid fossa of the scapula (Clippinger, 2007). In return, these muscles keep the integrity of the shoulder region.

Shoulder stability is a concern for dancers in helping to maintain the structural integrity. Since the shoulder allows for many movements in a great range of motion, it can cause instability. Shoulder instability occurs when the humeral head is unable to remain in the glenoid fossa (Weiss et al., 2008). In some cases, the humerus may partially come out of the shoulder socket, called a subluxation (Weiss et al., 2008). The humerus can also slip out entirely; this is referred to as a dislocation (Weiss et al., 2008). When an injury occurs normal joint stability is
compromised. There are different ways the structure is compromised and one is from repetitive strain. The American Academy of Orthopedic Surgeons (AAOS) states repetitive strain occurs when a person has very loose ligaments in their shoulders. (AAOS, 2013). Loose ligaments are the cause of hypermobile joints, which allows for greater range of motion but also hinders the stability of a given body region (AAOS, 2013).

Joint hypermobility in dancers is associated with its advantages and disadvantages (McCormack, 2010). McCormack states that hypermobility is desired by dancers because it allows them to “achieve extreme positions,” such as the ability of a dancer to get their leg high in a grand battement (McCormack, 2010). Consequently, the hypermobile joint that produces these extreme ranges of motion is guarded by a lax capsule and ligaments (McCormack, 2010). As a result, the joint is compromised becoming “less stable, weaker, and more susceptible to injury than a normal joint” (McCormack, 2010). The consequence to this is decreased proprioception, which affects posture, balance, and coordination (McCormack, 2010). Embedded in the joint capsules and ligaments are sensory nerve endings that inform the central nervous system of the body’s position, movement, and rate in which movement is occurring (McCormack, 2010). When tissues stretch and become hypermobile the proprioceptive feedback becomes less efficient (McCormack, 2010). McCormack states “it is the sensory part of the nervous system that allows us to appreciate acutely the position of our limbs in space, be it joint position or muscular activity” (McCormack, 2010).

Dancers with hypermobile joints and weak muscles supporting the structure of the shoulder are subjected to instability (McCormack, 2010). These factors are important to acknowledge since they may indicate the risk of injury for those participating in modern dance. The shoulder complex plays an important role for the modern dancer. Modern dancers are
required to transition from standing upright to being upside down, by using their upper-body as a base to support the weight of the entire body. These repetitive and extreme weight-bearing demands put the dancers’ upper-body musculature at risk for injury. If using improper body mechanics paired with insufficient strength and endurance to meet the demands, it can impact the musculature (joints and ligaments of the shoulder). With time, this may produce similar injuries seen in overhead athletes, such as tennis and volleyball players.

With the increased demands for modern dancers to perform weight-bearing activities, most specifically the repetitiveness of overhead motions, modern dancers may be susceptible to similar injuries as seen in overhead athletes. It is reported that the shoulder is at high risk of injury in overhead athletes, such as swimmers, tennis and volleyball players that require repetitive overhead motions that stretch out the shoulder ligaments (AAOS, 2013; Cools et al., 2015). The most reported types of shoulder injuries are rotator cuff strains and with time leading to injury. Overhead athletes can experience chronic shoulder pain and are often attributed from sport-specific adaptations, alterations in strength, flexibility, and posture in the glenohumeral joint, as well as other links of the kinetic chain (Cools et al., 2015; Lintner et al., 2008). Cools et al., 2015 states that the alterations in biomechanics and movement strategies can lead to glenohumeral internal-rotation deficit (GIRD), rotator cuff strength imbalance, scapular dyskinesia, thoracic spine stiffness and hyper-kyphosis, and lumbar core instability. Researchers believe glenohumeral range of motion, rotator cuff strength or imbalance, and scapular position and movement are important factors in assessing the shoulder (Cools et al., 2015). Assessing the shoulder is important since it can potentially provide insight into faulty movement links, which may affect other areas of the body.
The Kinetic Chain and Faulty Links

The kinetic chain concept is important in understanding how one region of the body impacts another biomechanically. McMullen et al., 2000 states “in activities of sport and daily life, the body does not operate in isolated segments” (McMullen et al., 2000). Instead, the body works as a dynamic system where everything interconnects (McMullen et al., 2000). When one part is not working to its fullest capacity, it hinders the performance of other areas (ACSM, 2012). Poor biomechanics enable a person to move efficiently by overcompensating for failing links (ACSM, 2012). This can cause poor movement patterns, which can create muscle imbalances, and eventually result in injury. For instance, Clippinger describes dancers’ inability to appropriately use muscles that connect the arms to the torso to produce movement (Clippinger, 2007). She claims that some dancers with inadequate shoulder flexibility will compensate to reach the arms to a vertical position, by arching the back (Clippinger, 2007).

According to the American College of Sports Medicine, “the ability to understand how the body and all of its segments work together is essential for developing effective exercise programs” (ACSM, 2012). The ability to create exercises programs that will meet the specific demands required of dancers for a particular style of dance can help increase performance. Within this process, it may provide the opportunity to also educate dancers on how to apply these concepts in and outside of class. This will promote dancers’ autonomy and potentially prevent injuries.
CHAPTER 2:  
MODIFIED PUSH-UP TEST  
Assessment Tools for Athletes

Since injury in any physical activity is of great concern, methods of identifying those at risk have been made in hope of injury prevention. There are numerous physical fitness tests that have been used to assess fitness parameters. For instance, the shoulder girdle and arm’s muscular strength and endurance can be measured with tests that involve either isometric or isotonic contractions of the muscles and are performed to exhaustion. Some field-based tests include push-ups, pull-ups, chin-ups, and the flexed-arm hang (Wood, 2004). Professionals in the dance field, such as educators, dance companies, and physical therapists have recognized the need to assess dancers’ physical well-being. The International Association of Dance Medicine and Science (IADMS) have stated the goal of screening is to help identify poor movement patterns that are the result of imbalances and instabilities of the body that can potentially cause injury.

The dance science field is relatively new and since 1990 the International Association for Dance Medicine and Science (IADMS) was established to promote dancers’ well-being (Liederbach et al., 2007). IADMS aims to promote “standardized measurements associated with dancer health, including the measurement of injuries themselves” (Liederbach et al., 2007). After this organization formed, several attempts have been made to research dancers’ physical capacity in order to promote optimal performance and decrease the chances of injury. Many of these research papers and testing heavily focus on the ballet dancer (Shah et al., 2012). For instance, Martinez et al., 2014 study aimed to compare balance control, hamstring flexibility and range of motion of the hip rotators between competitive and recreational ballet dancers (Martinez et al.,
Martinez et al., 2014 used the Star Excursion Balance Test (SEBT) to assess the ballet dancers’ balance. The researchers of this testing concluded experienced and older dancer develop better balance than younger dancers. However, in relation to the SEBT results, showed recreational dancers exhibited better balance (Martinez et al., 2014). Research and testing performed on dancers have helped professionals obtain a greater understanding of many aspects of dancers’ well-being, such as biomechanics and its relation to injury prevention. Although incidence, risk factors and management of musculoskeletal injuries in ballet dancers’ have been examined, there is a need in researching modern dancers (Ambegaonkar et al. 2012). Shah et al., 2012 has stated, “modern dance has become increasingly popular, yet little has been reported with respect to modern dance injuries and their consequences” (Shah et al., 2012).

Like other dance genres, modern dance has its’ own physical demands that distinguish it from other styles of dance. Ambegaonkar et al. stated “modern dance has been consistently suggested to have more upper-body movements and overall higher upper-body demands than other dance genres” (Ambegaonkar et al. 2012). Consequently, Ambegaonkar et al., 2012 has reported modern dancers have sustained twice as many upper-body injuries than ballet dancers (Ambegaonkar et al., 2012). Accordingly, it is suggested that collegiate modern dancers have high upper-body injury rates (Ambegaonkar et al., 2012; Sides et al., 2009).

Angioi et al. 2009 have suggested that fitness parameters, such as strength, muscular endurance, and power influence risk of injury (Angioi et al., 2009). For this reason, the modified push-up test is recommended by the American College of Sports Medicine to examine the upper-body strength and muscular endurance (Riebe et al., 2016). Ambegaonkar et al., 2012 has stated “the push-up test is a comprehensive field-based measure of fitness for the upper-body (Ambegaonkar et al., 2012)
What Is The Modified Push-Up Test?

The modified push-up test is a variation of the push-up test and is usually the standardized testing for female participants. It is an accepted measure of upper-body fitness (Ambegaonkar et al., 2012; Riebe et al., 2016). The push-up test is one of the assessments measuring physical capacity that army personnel is required to pass to remain active in the Armed Services. In addition, Military personnel ranging from the Army, Coast Guard, Navy, and numerous NATO-wide armed forces implement this physical fitness test (PFT) (Fielitz et al., 2016). The push-up test is used to assess and develop shoulder-arm and upper body strength/work capacity. The benefit of the test protocol allows for many people to be tested in a short period of time and without additional equipment (Fielitz et al., 2016).

Aside from being used as a screening evaluation, the push-up test can provide information about a person’s baseline physical fitness level. The results obtained from testing can be compared to established standards and can be “helpful in identifying weaknesses in certain muscle groups or muscle imbalances” (Riebe et al., 2018). Riebe et al., 2018 suggests that identified muscles can be targeted in exercise training programs (Riebe et al., 2018). In addition, the results can be used to track the upper-body strength and muscular endurance over time to assess progress (Riebe et al., 2018). For these reasons, researchers have used the push-up test to examine sports involving overhead movements in order to assess athletes (Fielitz et al., 2016). The goal of these researchers is to gain more knowledge of the athletes’ physical fitness.

The modified push-up test has also gained some attention in examining associations between fitness measures and dancer’s musculature (Angioi et al., 2008). Ambegaonkar et al., 2008 used the modified push-up test to compare the upper-body endurance in female university
level modern dancers and physically active non-dancers. From this study, researchers concluded both groups had similar upper-body endurance (22.2 ± 8.6 vs. 19.9 ± 8.2, p = 0.44) (Ambegaonkar, 2012). The probable cause of both groups’ similar results exists in the lack of physical activity outside of dance training (Ambegaonkar, 2012).

**Researching Collegiate Dancers’ Upper-Body Strength and Muscular Endurance**

The purpose of this study was to assess collegiate dancers’ upper-extremity strength and muscular endurance using the Modified Push-Up Test. Fitness tests can be an informative tool for indicating those at risk for injuries. This is important for safely transitioning dancers into a modern technique class where physical demands differ from other dance genres. This can ultimately decrease the chances of injury from occurring when annually, dance-related injury rates are reported to average between 67-95% (Fuhrmann et al., 2010). In addition to injury prevention, this may be informative to dance educators with their role of helping students meet the physical demands of modern dance. This is accomplished by recognizing modern dance specific exercises to incorporate in their technique classes.

By using the data of the participants performing the modified push-up test, observations of the participant’s deviations from proper body alignment were noted according to the displacement of tape landmarks placed on the body (location of landmarks further discussed in testing procedures). By watching the video recordings of the participants performing the test, I took note of any deviations from proper body form as specified by The American College of Sports Medicine’s protocol: the spine not maintaining a straight line, stomach touching the mat, elbows not fully straightening at the end of the push-up, and chin not touching the mat when the participant lowers down for the push-up (Riebe et al., 2016). Displacement of the body is often
associated with muscle imbalances (Riebe et al., 2016). Stronger muscles overcompensate for weaker muscles when weaker muscles do not match the strength and endurance of stronger ones (Riebe et al., 2016). The weaker muscles fatigue more easily, causing the stronger muscles to work harder (Riebe et al., 2016). This is an indicator of what muscles can be strengthened to help ballet dancers transition to a modern dance class where upper-extremity movement is demanded.

Muscular Strength and Endurance Defined

Baumgartner et al. define muscular strength as the maximum force that can be generated by a muscle group during a short period of time. Muscular endurance is the ability to exercise muscle groups over an extended period of time at moderate intensity utilizing aerobic energy and to resist fatigue. A general definition of arm and shoulder girdle strength and endurance is the ability of the arm and shoulder girdle muscles to move the weight. A field-based definition is the ability to move or support the body weight against the pull of gravity (Baumgartner et al., 2003).

Muscular power, strength, and endurance have an influence on the risk of potential injuries (Clippinger, 2007; Ambegaonkar et al., 2012). Clippinger refers to muscle function as a “continuum from power to strength to endurance (Clippinger, 2007). Wilmerding et al. states “in dance you are required to jump, catch partners, move down onto the floor and up out of the floor at fast speeds, and perform other explosive movements” (Wilmerding et al., 2017). These movements require the dancer to have adequate levels of muscular strength and power in order to meet these physical demands. Wilmerding et al., 2017 implies that some technique classes do not require the dancer to perform sufficient repetitions to develop strength, power, and endurance (Wilmerding et al., 2017). This causes concern, as the musculoskeletal develops imbalances which can lead to injury (Wilmerding et al., 2017). For this reason, it is suggested that the
overload and specificity principle is applied to fitness regimens to increase performance and as a result, decrease the chances of injury from occurring (Riebe et al., 2018).

**Overload and Specificity Principle**

When an athlete’s body becomes accustomed to their exercise training program, adaptation fails to occur without a greater stimulus (Riebe et al., 2018). The American College of Sports Medicine’s (ACSM) guideline for increasing muscular strength is through the overload principle. The overload principle is the concept of progression by increasing resistance, the number of sets, or frequency of training (Riebe et al., 2018). Dancers who rely on technique classes as a training regimen are only subjected to the demands required of that dance genre. This is known as the principle of specificity which implies that to become better at a particular skill, one should replicate movement patterns of that skill (Riebe et al., 2018). This is a common practice for ballet dancers who believe any outside training will compromise aesthetic quality (Kozai, 2012).

Dancers abiding by the principle of specificity face the challenge of their body adapting to their technique training. Without supplemental training, the body is not stressed beyond what it is accustomed to (Riebe et al., 2018). This is of concern when dancers must participate in another form of dance that is unfamiliar and the demands require different physical skills than what is practiced. For instance, in Ambegaonkar et al., 2008 study comparing modern dancers and non-dancers’ upper body muscular endurance, the results indicated no significant difference between the two populations (Ambegaonkar et al., 2008). The researchers concluded that dance alone, may not promote the necessary muscle gains needed to be successful in modern dance (Ambegaonkar et al., 2008). As a result, the overload and specificity principle may be beneficial for dancers to promote their physical capabilities to meet the demands of modern dance.
CHAPTER THREE:  

METHODS  

Methods for the Modified Push-Up Test

The purpose of this research study was to investigate the upper-body strength and muscular endurance between collegiate modern and ballet dancers, by using the American College of Sports Medicine’s (ACSM) protocol for the Modified Push-Up Test (Riebe et al., 2016). Consent for this research was granted by the University of California, Irvine’s Institutional Review Board (IRB) on July 20, 2017. The lead researcher posted flyers in the dance studios, dance bulletin boards, and on Facebook for recruitment of participants. In addition, the dance department sent emails to the undergraduate dance majors with the recruitment flyer attached to it.

Consent and Eligibility

The research study was conducted through the Claire Trevor School of the Arts Dance Department at the University of California, Irvine. Subjects that were eligible to participate in the study needed to meet the following inclusion criteria: each participant was at least eighteen years of age, full-time currently enrolled undergraduate dance major in the dance department, and no previous or current injury that may prevent completing the test. Participants were required to sign a consent form prior to being tested.
Materials Used During Testing

Table 1: Materials for Testing

<table>
<thead>
<tr>
<th>Material</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yoga mat</td>
<td>Protect the subject’s knees while in the modified push-up position</td>
</tr>
<tr>
<td>Painters tape</td>
<td>Mark participant’s body as visual landmarks, for later analysis</td>
</tr>
<tr>
<td>Video recorder</td>
<td>Record participants performing the test</td>
</tr>
<tr>
<td>Timer</td>
<td>Keep time</td>
</tr>
<tr>
<td>Spotter</td>
<td>To stop the participant if they strain forcibly or unable to maintain correct technique within two consecutive push-ups</td>
</tr>
<tr>
<td>ACSM modified push-up protocol</td>
<td>To read and give participants directions for testing</td>
</tr>
<tr>
<td>Data collection sheet</td>
<td>To record the amount of errors performed during testing</td>
</tr>
<tr>
<td>Participant folder</td>
<td>Containing consent and questionnaire forms</td>
</tr>
</tbody>
</table>

Testing Procedures

After subjects signed the consent forms and filled-out a questionnaire, the lead researcher used painters tape to mark visual landmarks on the subject’s body for observational purposes. Markers were placed in three different areas located on the lateral side of the body: approximately an inch below the greater tuberosity of the humerus, along the iliac crest, and the head of the fibula. After the landmarks were taped, the lead researcher demonstrated the “modified push-up” position and read the instructions to the subject as they are written in the American College of Sports Medicine’s protocol for the modified push-up (Riebe et al., 2016). Each session was approximately ten minutes per participant.
ACSM Modified Push-Up Protocol

The modified push-up test as described in the American College of Sports Medicine’s Guidelines for Exercise Testing and Prescription was adhered to. To measure the participant’s upper-body strength and muscular endurance the participant starts in a modified “knee push-up” position. The hands are shoulder width apart and elbows fully extended, legs and ankles together and lowered on a mat, the head is up, using the knees as the pivotal point (Riebe et al., 2016). While maintaining a straight line from the knees, to the hips, and to the shoulders, the participant lowers the upper-body until the chin touched the mat (Riebe et al., 2016). The participant then raises the upper-body to the starting position until elbows were fully straightened (Riebe et al., 2016). The participant’s stomach is not allowed to touch the mat, and the back is required to be straight (Riebe et al., 2016). The test was stopped if the participant strained forcibly or was unable to maintain correct technique within two consecutive push-ups (Riebe et al., 2016).

Figure 1: Modified Push-Up Position. Retrieved from http://aibolita.com/fitness/31240-muscular-endurance.html
The Modified Push-Up Test Norm Grading Scale

The maximum number of push-ups the participant was able to perform in correct body alignment was used as a score. Errors were credited to the subject when any of the following occurred:

- The back (spine) deviated from a straight line
- Stomach touched the mat
- Elbows did not fully straighten at the end of the push-up
- Chin did not touch the mat

The score was ranked according to the standards from the American College of Sports Medicine’s norm grading scale, matching the participant’s gender, age, and modified push-ups performed (Riebe et al., 2016). These factors correlated with categories, consisting of “Poor,” “Fair,” “Good,” “Very Good,” and “Excellent” (Riebe et al., 2016).

Table 2: Fitness Categories for the Push-up by Age and Sex

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60-69</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>W</td>
<td>M</td>
<td>W</td>
<td>M</td>
</tr>
<tr>
<td>Excellent</td>
<td>≥36</td>
<td>≥30</td>
<td>≥30</td>
<td>≥27</td>
<td>≥25</td>
</tr>
<tr>
<td>Very good</td>
<td>29-35</td>
<td>1-29</td>
<td>22-29</td>
<td>20-26</td>
<td>17-24</td>
</tr>
<tr>
<td>Good</td>
<td>22-28</td>
<td>15-20</td>
<td>17-21</td>
<td>13-19</td>
<td>13-16</td>
</tr>
<tr>
<td>Fair</td>
<td>17-21</td>
<td>10-14</td>
<td>12-16</td>
<td>8-12</td>
<td>10-12</td>
</tr>
<tr>
<td>Poor</td>
<td>≤16</td>
<td>≤9</td>
<td>≤11</td>
<td>≤7</td>
<td>≤9</td>
</tr>
</tbody>
</table>
Data Collection

Individual folders were created for each participant. Data was collected and organized by lead researcher and kept in a secured locked drawer to comply with IRB protocol. The primary outcomes of this testing were analyzing and comparing modern and ballet dancers’ upper-body strength and muscular endurance using the American College of Sports Medicine’s norm grading scale.
CHAPTER FOUR:

RESULTS

Participant Demographics

A total of thirty undergraduate dance majors from the University of California, Irvine Department of Dance were recruited for this investigation. Females were the most represented gender in this study (N=27) in comparison to male participants (N=3), accounting for an 80% difference between female and male participants (Table 3). Dancers were an average of 19.9 years of age (range: 18 to 30 years). Fourteen freshmen were the most represented class of undergraduates with 47% and sophomores were the least represented with two dancers (7%) (Table 3).

Table 3: Enrolled Subjects

<table>
<thead>
<tr>
<th>Gender</th>
<th>Females N=27; 90%</th>
<th>Males N=3; 10%</th>
<th>Year in School</th>
<th>Freshmen N=14; 47%</th>
<th>Sophomores N=2; 7%</th>
<th>Juniors N=4; 13%</th>
<th>Seniors N=10 33%</th>
</tr>
</thead>
</table>

Asians were the most represented race from the general population at the University of California, Irvine Department of Dance (N=15; 50%), followed by Caucasian (N=8; 27%), Hispanic (N=4; 13%), and then African American (N=3; 10%) (Figure 2).
Results of Questionnaire

Dancers were asked to report which dance genre they most identified with. Of the thirty participants, twenty-one identified themselves as modern dancers (70%) and nine as ballet dancers (30%) (Table 3). Modern dancers accounted for the majority of participants in this study, with a 40% difference between the two dance forms.

There were twenty-seven females in this study, contributing to the overall most represented sample in this study by 90% (Table 3). More specifically, female modern dancers (N=18) made up 60% of subjects. In similarity, 30% of dancers who identified as ballet dancers were female (N=9). Male participants were the most underrepresented gender in this investigation (N=3). All three participating males identified as modern dancers. There were no reported male ballet dancers present in this study.
Participants were also asked to state if they participated in supplemental exercise training and to specify what kind. The results indicated a total of 57% of dancers ($N=17$) engaged in alternative exercises outside of their dance technique classes (Figure 4). In contrast, 43% of dancers did not participate in any ($N=13$) (Figure 4). In total, modern dancers attributed to 65% ($N=11$) of participants not partaking in supplemental exercise training programs, whereas ballet dancers only accounted for 23% ($N=3$) (Figure 4).

The two most favored forms of alternative exercises were Pilates and yoga (Figure 4). Dancers who participated in these two methods accounted for 77% of participants who engaged in any form of exercise outside of dance classes. Twelve dancers practiced the Pilates method and eleven practiced yoga (Figure 4). In contrast, only five participants engaged in some type of strength training and three in cardiovascular-based exercises (Figure 4).
Modified Push-Up Errors

The amount of push-ups performed in proper form was only counted towards the final score for each participant. The criteria that defined proper form were the participant’s ability to maintain a straight line of the spine without the stomach touching the mat, and completing each push up with elbows fully straightened (Riebe et al., 2018). Modern dancers scored a mean of 8.24 errors, while ballet dancers received a mean of 4.11 (Figure 5). Modern dancers had a higher mean score in comparison to ballet dancers by 4.13.

Figure 4: Types of supplemental training participants engaged in outside of their dance classes.
Figure 5: This figure is representative of the mean and sample standard deviation (mean ± SD) from the scores of each push-up performed in proper form.

Modified Push-Up Results Compared to ACSM Norm Grading Scale

The final scores received by participants were compared with the American College of Sports Medicine’s grading norm scale (Riebe et al., 2018). Along with the participants’ score, their age and sex were also factors influencing the category they were classified under, as illustrated in Table 4.
Table 4: Fitness Categories for the Push-up by Age and Sex

<table>
<thead>
<tr>
<th>CATEGORY</th>
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</tr>
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</tr>
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<td>17-21</td>
<td>13-19</td>
<td>13-16</td>
</tr>
<tr>
<td>Fair</td>
<td>17-21</td>
<td>10-14</td>
<td>12-16</td>
<td>8-12</td>
<td>10-12</td>
</tr>
<tr>
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<td>≤16</td>
<td>≤9</td>
<td>≤11</td>
<td>≤7</td>
<td>≤9</td>
</tr>
</tbody>
</table>

Table 4. Fitness Categories for the Push-up by Age and Sex (Riebe et al., 2016)

The scores received by participants in accordance to the American College of Sports Medicine’s (ACSM) norm grading scale identified 63% of participants as having “poor” upper-body strength and muscular endurance (Figure 6) (Riebe et al., 2018). Of the remaining participants, 27% were classified as “fair,” and 10% “good” (Riebe et al., 2018). None of the dancers received “very good” or “excellent” in respect to the norm grading scale established by ACSM (Riebe et al., 2018).

Of the participants who received a score indicating their upper-body strength and muscular endurance fitness level as “poor,” 63% were from modern dancers and 37% were ballet dancers. In addition, modern dance participants accounted for maintaining the highest percentage for each grading category on the ACSM grading scale (Riebe et al., 2018). Modern dancers contributed to 87.5% of “fair” scores and 67% of “good” (Riebe et al., 2018).
Figure 6: This figure represents the scores dancers received in accordance to the American College of Sports Medicine’s (ACSM) norm grading scale for the modified push-up test.

To further examine the scores received between the two dance genres, a Mann-Whitney Test was used. The analysis revealed there was no statistical significance with a p-value, \( p=0.20 \) and a 90% confidence level (Figure 7). The result suggests there is no difference between modern and ballet dancers’ upper-body strength and muscular endurance, therefore rejecting the null hypothesis as originally stated in the Introduction.
**Figure 7:** The above figure is the analysis conducted by the Mann-Whitney Test examining the scores between modern and ballet dancers.

**Types of Errors Occurred During Testing**

There were a total of 203 errors that occurred during testing. Modern dancers accounted for the highest amount of errors with 127 (63%), while ballet dancers maintained less errors with 76 (37%) (Figure 8).
The most prevalent error among all participants was spinal deviation, accounting for 49.3% of all errors (Figure 9). Modern dancers accounted for 55% of spinal deviation errors with a 10% difference from ballet dancers, who contributed to 45% of the total. The second most common error by 47.3%, was the chin not lowering all the way down to the mat (Figure 9). Modern dancers attributed to 75% of the total error and ballet dancers only made up 25%. There were no errors were counted for participants not fully straightening their elbows after each push-up.

**Figure 8:** This figure illustrates the total amount of errors each dance genre received.

**Figure 9:** This figure represents the breakdown of how many errors occurred within each ACSM error category.

**Association of Pilates and Yoga with Scores**

Figure 10 illustrates the scores of participants who engaged in Pilates and/or yoga as alternative exercises. From the dancers who reported their participation in these alternative
exercises, 61% (N=14) ranked as “poor” according to the ACSM grading scale (Riebe et al., 2016). In addition, 26% (N=6) classified as “fair” and 13% (N=3) as “good” (Riebe et al., 2016).

![Results of Participants Engaged in Pilates and Yoga](image)

**Figure 10**: This figure illustrates the scores of dancers who stated they participated in Pilates and/or yoga.

**Observed Compensations of the Body**

After the lead researcher reviewed the recordings of participants, two common biomechanical compensations occurring during testing were observed. The lead researcher counted twenty-six participants’ inability to properly stabilize the hand on the ground during test and/or participants favoring one side of the body to accomplish push-ups (Figure 11). Thirteen errors were recorded for dancers’ inability to stabilize the hand. The mean of hand stabilization errors was 6.5.

Modern dancers maintained eight errors, whereas ballet dancers received five. There were a total of thirteen errors accounting for dancers favoring one side of their body. Modern
dancers had the most errors with ten, and ballet only received three. The mean of participants favoring one side of the body was 6.5.

**Figure 11**: This figure represents the lead researcher’s observations of compensations participants made while performing the modified-push up test.

There were a total of thirty dancers that participated in this study. Females (N=27) were the most represented population in this investigation by 90% (Table 3). In contrast, there were only 10% of male dancers (N=3) that were included (Table 3). Overall, females who identified as modern dancers accounted for 60% of all participants. Only 57% of participants reported partaking in supplemental exercise training outside of their dance classes (Figure 3). The two most favored alternative exercises were Pilates and yoga, accounting for 77% of participants who did exercise (Figure 3).

When further comparing the scores of modern and ballet dancers with a Mann-Whitney Test, results indicated a p-value of 0.20 and a confidence level of 90% (Figure 7). This indicates
that there is no significant difference in modern and ballet dancers’ upper-body strength and endurance. This finding also supports Ambegaonkar et al., 2012 study that revealed university-level modern dancers did not have better upper-body muscular endurance compared to non-dancers (Ambegaonkar et al., 2012).

There were a total of 203 errors noted during testing (Figure 8). Modern dancers maintained 63% of total errors and ballet dancers with 37% (Figure 8). As a result of these errors, dancers were classified as having “poor” upper-body strength and muscular endurance by 63% (N= 19) (Figure 6).

Of the dancers participating in this study, 43% reported no exercise training outside of their dance classes (Figure 4). This may have contributed to dancers receiving “poor” scores and supports the claim made by Ambegaonkar et al., 2012, that dance alone may not promote gains in upper-body strength and muscular endurance (Ambegaonkar et al., 2012). In addition, Ambegaonkar et al., 2012 suggested that not all alternative exercise modalities “may not improve physical attributes” (Ambegaonkar et al., 2012). In relation to Ambegaonkar et al., 2012 the results from this study did not indicate that participants engaging in supplemental training correlated with higher scores. Of the participants who engaged in Pilates and/or yoga as alternative exercises, 61% ranked as “poor” according to the ACSM grading scale (Riebe et al., 2016). This implies that not all alternative exercises may substitute for strength training programs that use the overload principle to promote upper-body muscle gains and endurance.
CHAPTER FIVE:

Discussion

In dance science literature it is suggested that modern dancers utilize more upper-body movements (Ambegaonkar et al., 2012). As an outcome of these physical demands, Sides et al., 2009 has reported a high incidence of shoulder injuries in collegiate modern students (Sides et al., 2009). Researchers have indicated that several fitness components, such as strength, muscular endurance, power, and balance are necessary for injury prevention and to improve performance (Angioi et al., 2009; Riebe et al., 2018). Although there have been many studies integrating these fitness components in sports to assess athletes’ physical well-being, few studies have yet examined the fitness levels of collegiate dancers, most specifically modern dancers (Ambegaonkar et al., 2012; Shah et al., 2012). This investigation aimed to compare collegiate modern and ballet dancers’ upper-body strength and muscular endurance.

The modified push-up test revealed that both groups had similar upper-body strength and muscular endurance levels (p= 0.20). In a study performed by Ambegaonkar et al., 2012 to compare university-level modern dancers’ upper-body muscular endurance to non-dancers, researchers discovered similar results with both groups having no significant difference in upper-body muscular endurance levels (Ambegaonkar et al., 2012). Ambegaonkar et al., 2012 concluded that modern dance alone may not produce the necessary muscular overload to “develop the requisite upper-body muscular endurance essential to preventing upper-body injury (Ambegaonkar et al., 2012).

Supplemental Exercise Training

In this study, over half of the participants’ modified push-up scores fall under the category of “poor” (N=19; 63%) when compared to the American College of Sports Medicine’s
norm grading scale. When analyzing the testing results with the number of participants who engaged in supplemental training (N=17; 57%), the physical activity levels of participants were not associated with higher scores. This may indicate that certain types of exercises may not promote a sufficient amount of muscular strength and endurance to withstand the physical tasks of modern dance.

The two most popular forms of alternative exercises were Pilates (N= 12) and Yoga (N=11), accounting for 77% of total participants training outside of dance classes. From the dancers (N=23) who engaged in either or both of these alternative exercise methods, 61% received a “poor,” 26% “fair and only 13% categorized under “good” according to the ACSM norm grading scale (Riebe et al., 2016). None of the participants received “very good” or “excellent” scores. Ambegaonkar et al., 2012 has suggested that these forms of training “do not adhere to the overload principle emphasized in strength and conditioning programs” (Ambegaonkar et al., 2012).

In the Pilates Method, exercises are designed to strengthen and stretch the body (Friedman et al., 1980). The lower abdomen and back are primarily focused on and do not push participants to the point of exhaustion (Friedman et al., 1980). Each exercise is typically performed between 3-5 repetitions (Friedman et al., 1980). Similarly to Pilates, yoga does not sufficiently promote strengthening and muscular endurance (Friedman et al., 1980). Friedman et al., 1980 has described Yoga as “static” in which rest, contemplation, stretching, and limberness is focused on (Friedman et al., 1980). In contrast, the American College of Sports Medicine (ACSM) recommends that a strength training program should include a person using a load of 60-70% of 1-RM and volume of 1-3 sets of 8-12 repetitions (Riebe et al., 2016). In addition, to improve muscular endurance a load lower than 70% of 1-RM and a volume of 2-4 sets of 10-25
repetitions (Riebe et al., 2016). In consideration to the ACSM guidelines for resistance training, participation in some alternative exercises may not improve physical attributes, such as upper-body strength and muscular endurance to meet demands of modern dance (Ambegaonkar et al., 2012).

**Modified Push-Up Errors: Spinal Deviation**

The most common error among all dancers was spinal deviation, accounting for 49.3% of errors. This error was primarily observed occurring in the lumbar region of the spine, as participants’ abdominals sagged to the floor and the pelvis was in an anterior tilt. Davenport et al., 2016 has stated “reduced endurance and increased fatigability of the trunk muscles is thought to lead to periods of instability in the lumbar spine” (Davenport et. al, 2016). This is of concern for dancers since the body acts as a kinetic chain, where one region of the body impacts another biomechanically (ACSM, 2012). Poor biomechanics can enable efficient movement as the body tries to overcompensate for faulty links (ACSM, 2012). The errors observed from participants performing the modified push-up test indicate that they have muscle imbalances. Oh et al., 2007 has stated lumbar hyperextension and anterior tilting of the pelvis is attributed to a deficit of abdominal control, weakness of the gluteus maximus, and dominant muscle activity of the erector spinae (Oh et al., 2007). This is of concern for dancers since the body acts as a kinetic chain, where one region of the body impacts another biomechanically (ACSM, 2012). The American College of Sports Medicine attributes the cause of most injuries to this factor, therefore if dancers do not correct these imbalances they may be at risk for injury (ACSM, 2012). For instance, Davenport et al., 2016 has suggested instability of the lumbar spine may predispose dancers to develop low back pain (Davenport et al., 2016).
Other Observations

There were two findings that were observed while analyzing the recording of participants. The first observation was hand instability. This was apparent as dancers gripped the mat with their fingers creating a cupped palm. This inevitably provided an uneven surface for the hands to act as support for the weight-bearing demands. Dionne states cupping the hands or lifting the fingers will directly put all the pressure and force on the wrist (Dionne, 2017). Instead, Dionne suggests to “ensure all parts of your hand and fingers are in contact with the ground to better disperse the force and avoid pain” (Dionne, 2017). The tendency for dancers to cup the hand and/or lift the fingers is important to recognize since modern dance movement phrases may require dancers to transition from standing upright to going into an inversion. If the hands are not in a stable position in which they can support the dancer, this may result in an injury.

The second observation was dancers favoring one side of the body to accomplish the push-ups as they began to fatigue. This observation supports Davenport et al, 2016 claim that most dancers have lateral biases in strength (Davenport et al., 2016). In relation, the American College of Sports Medicine (ACSM) states that stronger muscles will overcompensate for faulty links in the body (ACSM, 2012). This indicates that dancers were favoring one side of the body because the musculature was able to support them and allow them to use that strength to power through the push-ups. This is concerning since they run the risk of fatiguing the muscles to the point of where poor biomechanics are being practiced (ACSM, 2012).

Limitations and Future Recommendations

This research was limited to a sample of collegiate modern and ballet dancers. Modern dancers accounted for 70% of the total participants in the study (N= 21). In addition, 90% of participants were female (N= 27) while only 10% were male (N=3). A larger sample size of
ballet and male participants would be needed to better compare the results of the upper-body strength and muscular endurance of collegiate dancers.

The results of this investigation concluded 63% of participants had “poor” upper-body strength and muscular endurance (Riebe et al., 2016). It is possible that human error may have affected the outcome of the results, due to the lead researcher’s observations. For instance, the type of clothing worn by dancers (non-fitting) may have shifted the placement of the tape that was initially placed on dancers as reference points. This may have obstructed the lead researcher’s perception of the participant’s body alignment. A consideration for future research is for participants to wear form-fitting clothing during testing (ex: leotard, tights, leggings, etc.) to eliminate the possibility of clothes shifting the placement of tape marks.

The participants’ scores were compared to the American College of Sports Medicine’s norm grading scale. However, this grading scale starts at age 20, while 53% of participants (N=16) were under the age of 20. A different grading scale may have indicated different results in the category outcomes for participants. Therefore, a grading scale inclusive of all ages should be considered when comparing scores.

Of the dancers who engaged in supplemental training, 77% mainly participated in Pilates and yoga. These two forms of exercises tend to emphasize physical control of the body. For instance, Pilates exercises are to help promote stabilization of the body (Friedman et al., 1980). This implies that quality is desired over quantity. Sometimes quality is associated with performing movement slowly, which requires more effort of the body’s musculature. For this reason, it may be beneficial to perform the modified push-up test with some type of cadence. Therefore, using a metronome instead of self-paced as recommended in future testing.
The results of this investigation should be considered only as preliminary. Research following a larger sample size of dancers participating in modern dance over a period of time may provide further insight. By comparing participants’ initial and final scores, researchers can examine if modern dance increases upper-body strength and muscular endurance with continued participation and training.
CHAPTER SIX: Practical Application

This investigation offers insight to a small population of collegiate modern and ballet dancers’ fitness levels. The aim of this study was to compare the upper-body strength and muscular endurance between the two populations of dance genres. The results of the modified push-up test may allow early identification of dancers at risk of injury (Liederbach et al., 2013). This may provide dance educators and students with the information needed for intervention to reduce the chance of injury and improve performance.

How Can Dance Educators Prepare Students for Weight-Bearing Movement

In this section, two different concepts in how dance educators can facilitate and increase dancers’ knowledge in properly executing weight-bearing movements will be discussed.

Educate Dancers about Basic Biomechanical Principles

For dancers relatively new to the modern dance genre, they may not be familiar with performing upper-body weight-bearing activities. Weiss et al., 2008 has stated that 55% of female dancers begin their training in ballet, in which the lower-body is heavily focused on rather than the upper-extremity (Weiss et al., 2008; Angioi et al., 2009). This is important to acknowledge in order to transition students from primarily dancing on their feet to changing their relationship in space and having to perform movements that require them to be upside down, as demonstrated in an inversion (handstand). As a result, this causes the upper-body to take the load of weight-bearing in dynamic movement. Therefore, dancers need to make connections to how their bodies can accomplish these weight-bearing activities, by understanding fundamental biomechanical principles to build a relationship to the ground to meet the demands of modern dance. Two important concepts for dance educators to introduce to dancers are center of gravity
and base of support. This is important to introduce in a modern dance class since these factors affect stability and mobility in dynamic movement. Dancers are often required to perform movements that take them off-balance and in addition, are asked to sustain the unequal distribution of weight.

Typically, when the body is not in movement (static) the ideal posture falls within the plumb line creating a vertical projection (Whiting et al., 2015). This vertical projection is associated with a person’s center of gravity within the base of support (Whiting et al., 2015). Whiting et al., 2015 states if the projection moves outside the base of support, a person can become unstable and “will fall without corrective muscle action” (Whiting et al., 2015). In contrast, when the body is in motion the center of gravity and base of support play important factors in maintaining a balance of the body. Center of gravity is when the weight of an object is dispersed and everything is in balance (Whiting et al., 2015). With the body’s unique function to perform a variety of different movements, a human’s center of gravity can change with different positions (Whiting et al., 2015). The base of support is “the area within an outline of all ground contact points” (Whiting et al., 2015). Center of gravity and base of support is important because it is a factor in determining “stability and ability to move effectively” (Whiting et al., 2015).

Stability and mobility are important factors in successfully adapting to dynamic movement. Whiting et al., 2015 states when stability is at its highest point, this compromises the degree of mobility. This is characterized by a “large base of support, a low center of gravity, a centralized center of gravity projection within the base of support, a large body mass, and high friction at the ground interface” (Whiting et al., 2015). In the opposite of this spectrum of when stability is low, there is a high level of mobility (Whiting et al., 2015). Whiting states this occurs
with a “small base of support, a high center of gravity, a center of gravity projection near the edge of the base of support, a small body mass, and low friction” (Whiting et al., 2015).

Whiting et al., 2015 terms the concept of the stability-mobility continuum in which is described “in situations of imminent contact, we try to enhance our stability; when we want to move quickly, we try to increase our mobility” (Whiting et al., 2015). For instance, in preparation for impending contact of a dancer performing an inversion (handstand), the dancer will brace themselves by widening their base of support by keeping their arms shoulder distance apart or slightly wider, opposed to having the arms at the midline of the body for support. On the other hand, if the dancer needs to adjust the positioning of their inversion to stay upside down for a longer period of time, the dancer would need to change the posture of their body that would enhance their mobility. For example, the dancer can adjust their neck/head alignment to keep it in line with the rest of the spine so it is not cervical flexion or hyperextension throwing off the center of gravity. Understanding these concepts can potentially instill body awareness for dancers, in which they will be able to better identify and correct their own errors. As a result, this may decrease the chances of injury from occurring.

The Principle of Specificity to Promote Accomplishment of The Desired Skill

In order to prepare students to be successful in performing weight-bearing movements, the principle of specificity should be applied during class. The objective of specificity is to perform movements closely resembling the ones trying to be accomplished (Riebe et al., 2018). The advantage of applying this principle is that the body will meet the demands of the skill because it adapts to practice (Riebe et al., 2018). For instance, in ballet class students are prepared to execute a pirouette by layering skills that closely resemble the actions of it. While warming-up the body during barre exercises, typically integration of plié, elevé, balances on one
A leg on demi pointe will be required of dancers. These technical steps are in essence all the mechanics needed to perform a pirouette. In similarity, the specificity principle should also be applied to modern dancers. This can be done during warm-up and continue throughout class time. As a result, this can promote the transition of skills. Another positive aspect of applying this principle is that it targets the same muscles groups needed to execute the skill. In return, this sets up the student for meeting the physical demands to be successful in accomplishing the movement (Riebe et al., 2018).

Dancers’ Part in Cross-Training to Increase Upper-Body Strength and Muscular Endurance

Dancers need to be assertive in their training and engage in cross-training to increase their upper-body strength and muscular endurance. Several fitness components, such as strength, power, and endurance are required for injury prevention (Ambegaonkar et al., 2012). Ambegaonkar et al., 2012 has stated “university- level modern dancers may not experience the muscular overload through modern dance alone” (Ambegaonkar et al., 2012). Consequently, dancers may be susceptible to injuries and need to engage in supplemental exercise training, specifically strengthening. If addressed, this can promote the integrity of the musculature of the upper-body.

Progression of Upper-Body Weight-Bearing Movements

It is important for dancers to physically prepare their bodies to match the requirements of weight-bearing movements. There should be a progression in developing the upper-body strength and muscular endurance. For instance, some dancers may not have a sufficient amount of upper-body strength and endurance to perform push-ups in the plank position. In this case, it may be
appropriate to progress starting from a modified position, in which the knees are on the floor rather than a full plank. Where to start building upper-body strength and muscular endurance will be dependent on the physical capabilities of each individual, therefore this is another consideration to keep in mind when progressing in exercises.

The American College of Sports Medicine recommends that the overload principle is adhered to (Riebe et al., 2018). This principle states that increased resistance, number of sets, or frequency of training be applied in order to progress upper-body strength and muscular endurance (Riebe et al., 2018). This concept is further discussed in Chapter 5.

It is important for educators and dancers to address the demands needed to be successful in modern dance. It is the role of the dance educator to effectively integrate a layering of skills to increase their students’ performance. Thus may provide students with the knowledge and tools to practice safe biomechanics to decrease the risk of injury from occurring. In addition, it is the dancers’ responsibility to seek alternative strength training programs. Dancers should seek resistance programs that abide by the overload principle, in order to promote gains in upper-body strength and muscular endurance (Riebe et al., 2016). As a result, this may enhance their performance and reduce injury.
CHAPTER SEVEN:

Conclusion

In this study’s population of university-level modern and ballet dancers, there was no significant difference in upper-body strength and muscular endurance. In addition, there was not an association between the dancers’ engaging in supplemental training and higher scores during the modified push-up test. The findings of this study revealed that collegiate dancers have poor upper-body strength and muscular endurance levels. These scores suggest that dance educators should stress the value of conditioning outside of dance technique classes to their students. In addition, dancers need to take the initiative of incorporating upper-body strength and muscular endurance exercises into their exercise regimens. This is important for properly preparing students to be successful in meeting the physical demands required by modern dance. By adding supplemental training into dancers’ daily lives, this could ultimately increase muscle gain and muscular endurance. In return, promoting the integrity of the upper-body and decreasing risk of injury (Ambegaonkar et al., 2012).
REFERENCES


Interested in learning about your muscular strength and endurance?

- This study requires one visit
- To participate, volunteers need to be a full-time undergraduate dance major

For additional information, please contact lead researcher and graduate student Vanessa Kanamoto
vkanamot@uci.edu
APPENDIX B

Dance Research Questionnaire

Date: ____________

Birthdate: ____________

Participant ID ______

Age: ______

Race: ____________

Current year:
☐ Freshman
☐ Sophomore
☐ Junior
☐ Senior

Enrolled as a full-time student:
☐ Yes
☐ No

What genre of dance do you identify the most with?
☐ Classical ballet
☐ Contemporary ballet
☐ Modern
☐ Other: jazz, hip-hop, tap, etc.

Years of experience: ________

Do you engage in any supplemental training? Please specify (ex: weight training, yoga, Pilates, etc.)

How many times a week do you partake in this training and for how long? (ex: 3x a week for 30 minutes each training session)
APPENDIX B

Dance Research Questionnaire

How long have you been participating in this training routine?

Is there any history of upper-extremity injuries? If so, please specify:

Please specify any injuries that may interfere while testing:
APPENDIX C

Modified Push-Up Protocol

Modified Push-Up Test

The Modified Push-Up Test provides a portable, cost-effective, and objective method of assessing upper-body strength and muscular endurance. The information gathered from this assessment tool can be used to identify muscle imbalances, which addressed can help reduce the chances of injuries.

The Modified Push-Up Test can be performed in nearly any environment and takes approximately 2 minutes to conduct.

Materials

1) Testing surfaces
   - yoga mat

   The purpose of the yoga mat is to protect the subject’s knees that will be in a modified push-up position.

2) An assistant to act as a spotter
   - the spotter is necessary to stop the subject if they strain forcibly or unable to maintain correct technique within two consecutive push-ups.

3) Modified Push-Up Protocol
   - these instructions should be read to the subject during administration of the Modified Push-up test.

4) American College of Sports Medicine’s (ACSM) modified push-up grading scale (See end of document)
APPENDIX C

Modified Push-Up Protocol

Modified Push-Up Administration

1) Before administering the Modified Push-Up Test, the following materials should be present:
   - yoga mat
   - tape
   - spotter
   - timer
   - Modified Push-Up Protocol- ACSM modified push-up grading scale.

2) Read the instructions to the subject as they are written in the ACSM Modified Push-Up Protocol.

3) Subjects will perform the test and will be recorded.

Scoring the Modified Push-Up Test

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60-69</th>
</tr>
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<td>M</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>≥36</td>
<td>≥30</td>
<td>≥30</td>
<td>≥27</td>
<td>≥25</td>
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<td>20-26</td>
<td>17-24</td>
</tr>
<tr>
<td>Good</td>
<td>22-28</td>
<td>15-20</td>
<td>17-21</td>
<td>13-19</td>
<td>13-16</td>
</tr>
<tr>
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<td>10-14</td>
<td>12-16</td>
<td>8-12</td>
<td>10-12</td>
</tr>
<tr>
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<td>≤16</td>
<td>≤9</td>
<td>≤11</td>
<td>≤7</td>
<td>≤9</td>
</tr>
</tbody>
</table>

Fitness Categories for the Push-up by Age and Sex (Riebe et al., 2016)
The number of push-ups the participant is able to perform without errors or deviations from proper form is counted. The examiner will begin counting errors only after the individual has assumed the proper testing position.

Errors: An error is credited to the subject when any of the following occur:

- The back (spine) deviates from a straight line
- Stomach touches the mat
- Elbows do not fully straighten at the end of the push-up
- Chin does not touch the mat

- The test will be stopped if the subject strains forcibly or is unable to maintain correct technique within two consecutive push-ups.


**Script for the Modified Push-Up Test Protocol**

Direction to the subject: I am now going to test your upper-body strength and muscular endurance.

I will describe the modified push-up position.
MODIFIED PUSH-UP POSITION:

**Direction to the subject:**

[Administrator demonstrates modified push-up position]

You will be on your knees with the hands shoulder width apart and elbows fully extended. The legs and ankles are together and lowered on the mat. The neck and head is in line with the spine while maintaining a straight line from the knees, to the hips, and to the shoulders.

You will bend at the elbows to lower the upper-body until the chin touches the mat, without the stomach making contact with the mat. You will then raise the upper-body to starting position until the elbows are fully straightened.

I will be counting the number of times you perform the push-up consecutively in proper form without rest. What I mean by proper form is: the back maintains a straight line, the stomach never touches the mat, and the elbows fully straighten at the end of each push-up. The test will be stopped if you start to forcibly strain or unable to maintain correct technique within two consecutive push-ups.

There will be a person positioned by you to help you get into the testing position and to stop you if you are unable to maintain correct technique.

**Direction to the spotter:** You are to stop the subject if they start to strain forcibly or unable to maintain correct technique within two consecutive push-ups.

**Direction to the subject:** Start in the modified push-up position with your hands shoulder width apart and elbows fully extended. The legs and ankles are together and lowered on the mat.

Testing will begin when you start lowering down for the push-up.
APPENDIX D

Modified Push-Up Data Collection Sheet

Name of task: Modified push-up

Purpose of the task: An objective measure of assessing upper-body strength and muscular endurance

Equipment needed: firm surface, yoga mat, IPad, tape

Step by step explanation on how to do each outcome measure:

Test:

1. The participant starts in a modified “knee push-up” position. The hands are shoulder width apart and elbows fully extended legs and ankles together and lowered on a mat, head is up and in line with the spine, using the knees as the pivotal point.

2. While maintaining a straight line from the knees, to the hips, and to the shoulders, the participant will lower the upper-body until the chin touches the mat.

3. The participant then raises the upper-body to the starting position until elbows are fully straightened.

The test will be stopped if the participant strains forcibly or is unable to maintain correct technique within two consecutive push-ups. This exam will take approximately 2 minutes.

Data Collection:

• Participant was recorded performing the modified push-up test

# of modified push-ups performed: ____________

# of errors: ____________

Errors: An error is credited to the subject when any of the following occur:

• The back (spine) deviates from a straight line
• Stomach touches the mat

• Elbows do not fully straighten at the end of the push-up

• Chin does not touch the mat