IDENTIFYING THE EFFECTIVENESS OF AN ONLINE DANCE-SPECIFIC PROTOCOL ON ALIGNMENT AND MUSCLE ACTIVATION IN UNIVERSITY DANCE MAJORS

Megan Shepherd

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Director of Thesis: Paul DeVita, PhD

Major Department: Kinesiology

Sagittal pelvic alignment is a key component in a dancer's ability to perform the physical tasks required of a dancer. To maintain and improve sagittal pelvic alignment and overall fitness, dancers must cross-train in other forms of fitness modalities to improve technique, flexibility, strength, and reduce injury occurrence. Few dance-specific conditioning protocols have been tested, and no dance-specific conditioning protocols have been tested in an online format for effectiveness in improving sagittal pelvic alignment and lower extremity muscle activation. We hypothesize dancers who receive online supplemental training as a dance-specific conditioning intervention will have improved pelvic alignment and lower-extremity muscle activation compared to dancers in the control group participating in an active self-selected fitness routine. The purpose of the study is to compare the effects of online dance-specific supplemental training versus the control group on pelvic alignment changes and lower-extremity muscle activation in university level dancers. 24 university level dancers (12 intervention group, 12 control group) participated in a 6-week dance-specific intervention protocol given in an asynchronous and synchronous online format. Interaction effects were observed through group by time 2x2 repeated measures ANOVAs, $p<0.05$. The 24 participants completed identical pre- and post-test kinematic and muscle analysis to assess sagittal pelvic alignment and muscle activation at various points during three dance phrases, two ballet phrases

and one modern phrase. The intervention group showed an improvement of 2.4° ($p<0.05$) in sagittal pelvic alignment through an interaction effect in ballet phrase 2, fifth position back. There was also a demonstrated group effect for the erector spinae in ballet phrase 2. However, these were the only two points of statistical significance and we were unable to identify the effectiveness of this protocol given in an online format. These findings suggest that a 6-week online dance-specific conditioning protocol is insufficient at improving pelvic alignment and muscle activation in dancers.

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Megan Shepherd

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APPROVED BY:

DIRECTOR OF
THESIS: ____
(Paul DeVita, PhD)

COMMITTEE
MEMEBER: ____
(Teal Darkenwald, MFA)

COMMITTEE
MEMBER: ____
(Nicholas Murray, PhD)

COMMITTEE
MEMBER: ____
(Patrick Rider, MS)

CHAIR OF THE
DEPARTMENT
OF KINESIOLOGY: ____
(Joonkoo Yun, PhD)

DEAN OF THE
GRADUATE SCHOOL: ____
(Paul J. Gemperline, PhD)

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Chapter I: Introduction

Dancers perform powerful physical feats that appear smooth, graceful, and effortless; therefore, dancers must cross-train in other areas of physical activity to achieve the maximum fitness level to perform more efficiently (Kozai 2012). Many dancers do high intensity interval training, cardiovascular training, and some perform resistance training for increased strength (Smith et al, 2013). Dance-specific conditioning is defined as, a combination of ballet barre, Pilates, yoga, somatics, and neuromuscular training exercises that target abdominal activation, pelvic alignment, whole body stability and strengthening, and range of motion. It can be performed using a barre for balance and support but also done lying down or kneeling on a mat. Dance-specific conditioning can provide many benefits to dancers because it not only provides supplemental training for dancers, but also reinforces postural and pelvic alignment, balance, and the balance between joint mobility and stability. Proper pelvic alignment is important to avoid injury and continue to improve a dancer's technique (Deckert et al. 2007). As more undergraduate dance programs move towards producing high caliber dancers, a dance-specific conditioning program would allow dancers to cross-train while also keeping their bodies in optimum alignment.

With the world still in a midst of a global pandemic, many dance classes have been forced to go virtual. Identifying whether online training is as effective as in-person classes is an important step during this period of virtual classes. A dance-specific conditioning class delivered online and to focused on pelvic alignment, dancers could supplement their training as they remain online. The literature available has looked at dance-specific conditioning protocols and pelvic alignment, many use dance-specific conditioning to improve pelvic alignment (Ahearn et al, 2018, Marinkovic et al, 2021). Of the studies that have been published none have implemented these protocols through an online format. An evaluation on instruction was given to students in a pre-professional dance program during the height of the pandemic for dancers in the Lyon National Conservatory of Music and Dance (Bruyneel et al. 2020). The main difficulty students and instructors noted during the study were lack of space at home, unstable internet connection, and difficulties with correcting dance movements without tactile feedback in an online format. However, both instructors and students appreciated the social aspect of the classes taught online and together they were able to develop an innovative pedological assessment to be reused once in-person classes were able to resume as normal.

Simply attending dance classes is not enough to keep a dancer in shape (Kozai 2012). A dancer must cross-train to reach their fitness potential both physically and mentally (Raferty 2010). A dancer's physical fitness is an important component to how well they can perform (Rodrigues-Krause et al, 2013). As the skill level or virtuosity of a dancer increases so does the intensity of movement, leaving a higher risk for injury (Twitchet et al 2010). Originally it was believed that ballet dancers had a higher level of anaerobic fitness than modern and contemporary dancers, studies now show that both types of dancers have an equal amount of anaerobic and aerobic fitness levels (Wyon 2012). Professional ballet dancers have a lower fitness level and increased risk of injury than athletes with similar workloads (Angioi et al, 2011). All dancers generally have high levels of anerobic and aerobic fitness capacities that are needed to achieve the difficult requirements of a dance performance (Kenny et al, 2017), but additional supplemental training is needed to reduce pelvic and postural miss-alignments.

No longer just focusing on the aesthetic view of dance, researchers are now interested in the movement and causes of movement in dancing (Angioi, Wyon 2009). In the past twenty-five years, the subject of dance biomechanics has come to the forefront of dance research. Through biomechanical analysis, the athleticism, and physical skills a dancer displays helps to inform and instruct dancers and teachers how a dancer can improve different aspects of dancing (Wilson, Kwon, 2008). Biomechanics, including kinematic analysis, can ultimately help a dancer to pinpoint faults (anatomical imbalances) in technique and the application of movement (Koutedakis 2008). By analyzing movement from a scientific point of view, a dancer can avoid injury to a degree and help to improve technique based on biomechanical analysis and not only through helpful tips from a teacher (Kenny et al, 2018). Dance biomechanics uses many tools and techniques found in traditional biomechanical analysis. Motion capture is widely used in dance biomechanics to capture and generate kinematic data from which kinetic data can be analyzed and used to evaluate the symmetry of dancer's movement (Tepla et al, 2014). Electromyography (EMG) to is used compare muscle activation in major muscle groups, for example, in dancers compared to non-dancers (Koutedakis et al, 2009).

Dancer's body awareness increases as they progress in their training. By implementing a dance-specific conditioning intervention in addition to their normal training, there is hope of enabling dancers to transition back into the studio after the pandemic with a minimal of an adjustment period (Wyon 2012). By focusing on pelvic alignment in a dance-specific conditioning intervention, dancers will be able to target key muscles in their gluteus, hamstrings, abdominals, quadriceps, and deep rotator muscle groups while continuing normal dance training. They may also add strength to maintain proper alignment with minute physical feedback

Hypothesis

This study will test the main hypothesis that dancers who receive online supplemental training as a dance-specific conditioning intervention will have improved pelvic alignment and lower-extremity muscle activation compared to dancers participating in an active self-selected fitness routine.

Purpose

The purpose of the study is to compare the effects of online dance-specific supplemental training versus self-selected fitness routines on pelvic alignment changes and lower-extremity muscle activation in university level dancers.

Delimitations

1. Participants must be between the ages of 18 and 23 years
2. Participants must be enrolled as a dance major or an intended dance major
3. Participants will have previous experience in various dance techniques
4. Participants will be healthy and have no current injuries
5. Participants are selected from East Carolina University's School of Theatre and Dance in Greenville, North Carolina

Operational Definitions

Supplemental training- other forms of fitness are used alongside dance training; can be anaerobic training, aerobic training, plyometric training, and weight training.

Dance-specific Conditioning- a combination of ballet barre, Pilates, yoga, somatics, and neuromuscular training exercises that target abdominal activation, pelvic alignment, whole body stability and strengthening, and range of motion. Exercises can be performed in supine, prone, kneeling, standing with balance assistance, and standing without assistance.

Chapter II: Review of Literature

Introduction

Dancers in a pre-professional program have a demanding schedule, typically focused on academic coursework, the development of artistic and technical skill, and improving their athletic capacity (Kenny et al 2017). With year-round training and no set season, dancers are at a high risk of injury due to fatigue and overuse. The need to stay healthy and fit is a necessity to prevent injuries (Deckert et al 2007). Supplemental training is a tool that dancers can use to prevent injury from happening to maintain overall fitness (Smith et al, 2013). The purpose of this study is to compare the pelvic alignment changes in dancers who receive supplemental online training compared to those who do not. Pelvic alignment can be tested motion analysis pre- and post-intervention. Muscle activation will be measured through wearable EMG to see if activation has decreased during the time of intervention. This review of literature will discuss the following concepts: dance biomechanics, dance injuries, and physical training for dance.

Dance Biomechanics

In the past twenty-five years, the subject of dance biomechanics has come to the forefront of dance research. No longer just focusing on the aesthetic view of dance, researchers are now interested in the movement and causes of movement in dancing (Angioi, Wyon 2009). Biomechanical analysis of the athleticism and physical skills of a dancer helps to inform and instruct dancers and teachers on how a dancer can improve in different aspects of dancing (Wilson, Kwon, 2008). Biomechanics can ultimately help a dancer to pinpoint faults (anatomical imbalances) in technique and the application of movement (Koutedakis 2008). By analyzing movement from a scientific point of view, a dancer can avoid injury to a degree and help to improve technique based on the biomechanical analysis and not only through helpful tips from a teacher (Kenny et al, 2018). Dance biomechanics takes many forms of normal biomechanical analysis.

Motion capture is widely used in dance biomechanics to capture and generate kinematic data from which kinetic data can be analyzed (Tepla et al, 2014). The symmetry of a dancer's movement has been widely studied through the aid of 3D motion analysis. Another form of biomechanical analysis that is performed on dancers is electromyography, using EMG technology to study major muscle groups in dancers in comparison to non-dancers has shown differences in postural and muscle control when performing balances and movements (Koutedakis et al, 2009). Dynamography and dynamometry are also used to perform biomechanical analysis of dance movements. These two forms of analysis involve looking at forces produced by movement and muscle torque within a dancer's body. These forms of data collection have been evolved over the last three-decades to have more accurate reading of dance, specifically when it comes to relating to dancer's bodies.

Dance Injuries

As important as it is to train, it is vital that a dancer get adequate periods of rest during the year as most dancers do not have a season and train and perform year-round. Dance, no matter the genre, has been deemed a high-risk activity that is prevalent during many instances involving injury (Kenny et al. 2016). Many dance companies, pre-professional programs, and some dance studios use a pre-screening to allow dancers to have a baseline indicator of performance pre-injury. A preparticipation evaluation (PPE-IP) focuses on specific psychometric and clinical tests that evaluate high risk factors for musculoskeletal injury (Kenny et al. 2017). This PPE-IP looks at body mass index, lower extremity range of motion, lumbopelvic control, and dynamic balance. If a dancer were to get injured during the season, they could take their preparticipation screening to a physical therapist to allow the physical therapist to know the level of function pre-injury and what that dancer needs to work on to get back to full function. By measuring fitness levels with heart rate, VO2max, isokinetic machines, and skinfold testing, dance scientists are able to get an accurate measure of a dancer's overall fitness.

While looking at body fat percentage, aerobic capacity, and many other things, the studies have concluded that aerobic capacity and body fat percentage, if at a low level, was significant in a dancer's injury risk. This helped to provide teachers, dancers, and physical therapists to be more informed when it comes to injury and time spent after injury to recover. Of the injuries sustained by dancers in the 15-week study, the injury that occurred "overuse" was the main cause in 8 out of 13 dancers (Twitchett et al, 2010). Another very common injury and issue among dancers is hip pain or hip injuries. Dancers must find a way to strengthen the hip joint and lessen the problems surrounding the hip joint. Pilates has been suggested as a good form of conditioning for dancers. Correcting the problem of hip laxity/hypermobility with strength training is the best option for dancers that way they don't lose range of motion or their ability to dance pain free (O'Sullivan et al, 2012). Taking into consideration the vast range of motion that is required in the hip joint of a dancer, many problems of hip impingement, hip dysplasia, arthritis, and many more problems are present in dancers. Hip pain and injury are the leading cause of lost work and performance time in professional dancers (Turner et al. 2012).

As outlined in Nikolaidis et al, (2012) study, training muscles eccentrically may lead to adaptations and injury within dancers. Dancers ultimately use more energy by eccentrically contracting muscles when performing movement. Nikolaidis et al, (2012) examined the adaptations, muscle expenditure, insulin resistance, and motor control that dancer's effect when using eccentric contraction. Concluding that prolonged eccentric exercise in dancers leads to delayed-onset muscle soreness and adaptations. The adaptations become a great concern when they lead to the disruption of motor control (Nikolaidis et al, 2012).

A dancer's schedule can be very demanding, and the difference of rehearsal compared to class is an interesting place to draw comparisons. Studies have taken data from dancers while monitoring their heart rate and VO_2 max while dancing throughout the entire duration of class and rehearsals. Blood work was also done on dancers pre and post activity. The study showed that heart rate and VO_2 max was lower in class than in rehearsal, proving what data has already provided a second time. The muscle damage done during exercise did not increase due to increased intensity. These results were informative and gave an insight to what dancers' bodies can endure during the rigorous weeks of rehearsal and class (Rodrigues-Krause et al, 2013). Koutdakis et al, (2009) provided information of a two-year recoding period of dance injury from 608 pre-professional and professional dancers. Concluding that the lover back (>225 injuries), knees (>175 injuries), and ankles (>150 injuries) were the most injured anatomical locations for dancers. Dancers that show excessive pelvic tilt, or lumbar lordosis, may be more at risk to low back, pelvic, and lower-extremity injuries. The question of just how much pelvic tilt is acceptable, both physically and aesthetically, was studied by Deckert et al. (2007) studied. Finding the average angle of acceptable pelvic tilt is 11.4°, anything above this degree of pelvic tilt, dancers have a higher risk of injury to this area and are not using proper pelvic alignment. It was shown in this study that out of 17 first year preprofessional dancers 12 had excessive pelvic tilt. These dancers required supplemental training, that focused on pelvic alignment and muscle activation (Deckert et al. 2007).

Physical Training for Dance

Studies show that just going to class is not enough to keep a dancer in peak shape (Kozai 2012). A dancer must cross train in order to reach their fitness potential both physically and mentally. Specifically, ballet dancers have a lower aerobic fitness level compared to athletes of the same caliber, and with a low aerobic fitness capacity ballet dancers report fatigue as the most common cause of decreased performance ability (Twitchett et al. 2011). Dancers' physical fitness is an important component to how well they are able to carry out performances and take class. As the fitness level of a dancer increases so does the intensity of movement, leaving a higher risk for injury.

Originally it was believed that ballet dancers had a higher anaerobic physical fitness than modern and contemporary dancers. More recent studies now showed that both types of dancers have an equal amount of anaerobic and aerobic fitness levels (Wyon 2012). Studies have shown that professional ballet dancers have a lower fitness level and increased risk of injury than athletes with similar workloads. Angioi et al. (2011) took that into consideration and had 8 dancers participate in a 1-hour per week fitness training regimen that involved aerobic interval training, circuit training, and whole-body vibration. The dancers were also tested on aesthetic performance pre- and post-intervention. Dancers who were a part of the ten-week intervention showed significant improvement in performance scores, indicating that it is beneficial to implement a fitness training program in a professional ballet dancers schedule (Angioi et al, 2011).

The demand on a dancer's body is slightly different between the genres of dance, but the same high level of anerobic fitness and aerobic fitness is needed to achieve the difficult choreography and requirements of a dance performance. An intervention of 10 1-hour sessions over 10 weeks investigated challenging a dancer's aerobic capacity by doing sessions of high-intensity interval training. The results were that dancers who were in the intervention group showed an increase of 400% in total performance score, 80% more control, and 100% more skill and virtuosity compared to the control group (Twitchett et al. 2011). Butulis et al. (2021) showed that dancers, like other athletes, benefit from supplemental training like any other athlete. In the study, cardiorespiratory fitness was assessed and proved that after a period of 12 supplemental training sessions dancers can improve muscular endurance and power in just 4 to 6 weeks. A study examining both static and dynamic postural stability showed demonstrated success in girls through modern dance training (Marinkovic et al. 2021). A noticed improvement in the dancer's use of proprioception compared to the control group of non-dancers. The standing balance test was used in this study to compare the dance group to the control group. Ahearn et al. 2018, found that dancers who participated in a Pilates based conditioning program over a period of 14 weeks dancers were able to improve postural alignment, flexibility, and abdominal strength. Pilates is very similar to dance movement in its emphasis on pelvic alignment, strengthening, and improving flexibility making Pilates an easily adaptable form of dance-specific supplemental training.

Another form of training for dancers is weight training and plyometric training. Weight training can help improve many aspects of their dancing, while maintaining the same level of mobility and aesthetic. With two intervention groups, one of plyometric training, focused on different jump training exercises, and a weight training group, focused on lower body muscle groups with use of machines, and a single control group the dancers in the intervention group showed improved jump height. The dancers in the intervention groups did not show any increase in total body weight or body fat percentage and the dancers in the control group showed that regular classes and rehearsals alone were not enough to improve strength, power, or jumping ability (Kozai 2012). In another study lower limb strength training was used to improve the height of a countermovement jump in dancers. Successfully showing, after 16 weeks of strength training the lower limbs, ballet dancers had an improved jump height from the supplemental training program (Ávila-Carvalho et al. 2022).

Summary

Through dance biomechanics studies, researchers have been able to pinpoint why injuries happen and how well supplemental training works in preprofessional and professional dancers. The added components of physical training can help improve alignment, aerobic and anaerobic capacities, jump height, and virtuosity in dancers, as well as prevent injuries.

This review of literature highlighted the development of dance biomechanics and the analysis that is used on dancers. This analysis has shown many researchers just how dancers bodies differ from non-dancers. With analysis developing more and more dance specific tests and measurement tools the intensity a dancer's body undergoes is being more widely understood and research is more accurate.

Injuries are prevalent in dancers at a higher rate than most high performing athletes of the same stature. Most injuries are due to the demands placed on a dancer's body with little to no rest in their season. Injuries in dancers are most associated with the lower extremities, but another factor in dance injuries is hypermobility and excessive range of motion dancers are capable of. These injuries sustained during the year can decrease performance capacity and take away time for training. While healing is important for a dancer's career steps and measures can be taken to prevent these common injuries from occurring.

Through physical training, specifically supplemental training, dancers can improve overall fitness capacities while maintaining the aesthetic appearance dance requires. Dance specific supplemental training has developed many intervention protocols that focus on strengthening, aerobic, and anaerobic programs. There are few focused on alignment specifically. The focus of this study will look directly into how supplemental training can improve pelvic alignment and influence lower-extremity muscle activation. The dance-specific conditioning protocol that is developed for this study will specifically focus on neuromuscular training to aid in alignment of the entire body with emphasis on the pelvis.

Chapter III: Methods

Introduction

This study tested the main hypothesis of: Dancers who receive online supplemental training as a dance-specific conditioning intervention will have improved pelvic alignment and lower-extremity muscle activation compared to dancers in the control group participating in an active self-selected fitness routine. The purpose of the study was to compare the effects of online dance-specific supplemental training versus the control group on pelvic alignment changes and lower-extremity muscle activation in university level dancers. In order to test this hypothesis participants were be recruited from an undergraduate dance program that focuses on ballet, modern, and jazz dance technique. In order to test pelvic alignment and neuromuscular activation, participants learned two ballet phrases and an athletic modern phrase that was be used to collect 3D motion analysis and surface electromyography data. Changes in pelvic alignment and muscle activation were compared with changes in these variables in a control group to test the effect of the online supplemental training. This section will provide a detailed description of the proposed methods, including the participant criteria, the equipment and instruments, the study design and procedures, the data processing, and the statistical analysis, needed to test these hypotheses.

Participants

This study aimed to recruit 30 undergraduate dance majors from East Carolina University's School of Theatre and Dance, we were successfully able to recruit 24 participants for this study. Participants were between the ages of 18 and 23, active dancers with at least two previous years of dance technique and conditioning. Participants were recruited through a volunteer basis and then randomly assigned into two groups, the intervention group, and the control group. On the first day of data collection, the participants filled out an informed consent document, that was approved by the University Institutional Review Board. Participants were screened through inclusion and exclusion criteria.

Inclusion criteria for the participants is as follows:

1. Participants must be between the ages of 18 and 23 years
2. Participants must be enrolled as a Dance Major, an intended dance major, or enrolled in a minor of dance. All participants have passed the audition process for the BFA program or minor approved by dance faculty.
3. Participants will have previous experience in ballet, modern, and jazz dance techniques
4. Participants will be healthy and have no current injuries
5. Participants provide written informed consent

Exclusion Criteria:

1. Participants will not be eligible for the study if they have had a major injury within the last year
2. Participants cannot be under the age of 18
3. Participants cannot be in another major or must be enrolled for a dance minor
4. Participants cannot be untrained dancers
5. Participants cannot be injured or pregnant

Based on these criteria, the participants were 23 females and one male, their mean age and standard deviation was 19.29 ± 1.08 years. The intervention group contained mainly 3rd year students with more years of experience in dance training and two years' experience in a university level dance program. The control group contained mainly 1st year students with less years of experience and no prior university level training.

Instrumentation

Participants were pre-screened through a medical questionnaire regarding injury and current health conditions. To collect kinematic data, 3D motion analysis was be taken with a 10-camera motion capture system (Qualysis OQUIS 300+, Göteburg, Sweden). Data were collected using Qualisys Track Manager Software (Qualisys AB, Göteborg, Sweden). The data were then analyzed using Visual 3D (C Motion, Germantown, MD). Surface Electromyography (DELSYS Trigno Avanti, Natick, Massachusetts) was used to collect muscle activation during data collection exercises.

Design

This was an experimental study from a volunteer basis. Participants were placed into the control group and the intervention group based off availability. This was an experimental study with a two-factor design: group and time.

Procedure

All testing was performed in the East Carolina University Biomechanics Laboratory (Ward Sports Medicine Building, 332) in Greenville, NC. Participants were randomized into the intervention group and control group upon arrival to the first day of data collection. The data collection protocol was separated into two different collections, a pre-intervention analysis, and a post-intervention analysis. During pre- and post-intervention data collection the participants were fitted with the sEMG markers. All participants were analyzed using the 10-camera motion capture system, pre and post intervention and recorded with a smartphone (iPhone 11 Pro, Apple, Cupertino, California).

Upon arrival to the Biomechanics Lab, participants provided written consent and filled out the Med Par Q that had been approved by the Institutional Review Board. The Med Par Q was used to screen dancers' health conditions, whether underlying or recent, in order to inform the PI if the dancer was at an acceptable level of health in order to participate in the study. This information was collected to ensure there was no prior injuries or major health concerns at the start of the study. The first week of pre-test analysis consisted of all participants learning and performing data collection exercises to be performed again in the post-intervention analysis. Participants learned these phrases from a video format and had a review period in the biomechanics lab in full marker set up before any data was collected to get them familiar with the space and the restrictions of the data collection setup.

Identical pre- and post-tests was employed for all participants. Volunteers from the School of Theatre and Dance participated in a three-dimensional (3D) assessment protocol. Additionally, a 3D video data collection was administered at the beginning and end of the 6-week intervention period with EMG data collection. To prepare the skin each participant was prepped with a lemon prep scrub applied to EMG sensor sights and wiped down with an alcohol prep pad. The EMG sensors were placed appropriately in the middle of the belly of the muscle to ensure a good read during muscle activation. The EMG electrodes were placed on the rectus femoris, vastus lateralis, gluteus medius, semimembranosus, external oblique, and erector spinae all on the right side of the participant's body. These muscles were selected because they provide the primary forces to stabilize and support the lower extremity and trunk and to move these body segments through space. Placing the electrodes only on the right side of the body allowed for data from a working leg when performing phrases on the right side, with the right leg moving, and data for the standing or supporting leg when phrases are performed on the left side and the left leg is moving. Each muscle group was tested for a maximum voluntary isometric contraction (MVIC) at both pre- and post-testing stages. These MVIC's were collected with the PI as a common resistance force for each participant. To collect the MVIC for the vastus lateralis and rectus femoris, participants were seated in a chair, dorsiflexed at the right ankle, and instructed to press into the PI, who had her hands placed on both the ankle and shin. The MVIC for the semimembranosus participants were prone on the ground, flexed at 90° at the right knee, and dorsiflexed at the ankle, and instructed to push into the PI, who had her hands placed on both the Achilles tendon and calf. The erector spinae MVIC was collected with the participants lifting their right leg behind them, to around 45°or 90°, while using a chair for balance and lifting the leg against the PI, who had her hands placed on both the thigh and calf. For the gluteus medius the participants lifted the left leg along the frontal plane at a 90° angle of flexion at the hip and knee, holding balance using assistance from a chair, and resisting the PI pressing the leg down with hands placed both on the calf and thigh. The final MVIC was collected for the transversus abdominis, participants were seated on the floor leaning back at a 45° angle and lifting both legs off the ground at a slightly flexed position, twisting along the transverse plane towards the right leg, while resisting the PI pushing into the knee and shoulder of the right side of the body.

The 3D motion capture markers were placed bilaterally on the iliac crests, anterior superior iliac spine, posterior superior iliac spine, greater trochanter, femoral medial condyles, femoral lateral condyles, medial malleolus, lateral malleolus, medial metatarsal, lateral metatarsal, thigh plates, shank plates, and foot plates. The marker plates were secured with wraps and duct tape to ensure they would not shift during data collection. The condensed label list can be found in (Appendix F). The PI completed a reliability study on 4 participants prior to the start of data collection to ensure marker placement accuracy. The accuracy of the PI's marker placement was sufficient to move forward with regular data collection.

Participants performed three different movement phrases for pre- and post-testing. These consisted of two ballet phrases and one modern phrase. Each ballet phrase was performed 3 times for the right and left sides, six times in total. These were performed on the right side, using the right leg as a working leg or leg doing movement, and the left leg as a supporting or standing leg with the left hand on the ballet barre. They were also performed on the left side, using the left leg as a working leg or leg doing movement, and the right leg as a standing or supporting leg with the right hand on the ballet barre. The ballet barre was a sturdy chair found within the Biomechanics Lab, because there was no access to a traditional ballet barre that would be present in a dance studio setting, a chair was used for balance. The phrase ballet 1 consisted of a series of battement tendus, battement dégagés, demi plies, and grande plies in first and fifth positions ending in a balance in first and fifth positions in relevé. The phrase ballet 2 consisted of a series of rond de jambes en dedans (towards the leg) and en dehors (away from the leg) with développés to en avant (to the front), a la seconde (to the side), and derriére (to the back) ending in a balance in full relevé in retire. The modern phrase was completed 3 times total and consisted of movements on the right and left sides. The modern phrase consisted of movements in parallel and turned-out positions, with inversions (hand on the ground feet in the air), jumps (tilt and double attitude), turns en dehors (outside) and en dedan (inside), as well as passes, parallel attitudes in derriére, and a penché balance. The turned-out position is defined as the outward rotation of the hip joint. Music was played for each phrase using a speaker and cued by the participant. Participants were given time to review the phrase with the PI and have it demonstrated by the PI for the first time on the right side for each ballet phrase. The PI demonstrated the modern phrase all three times during the pre- and post-test data collection sessions for each participant. Participants were also given time to rest and review in between captures while the PI was saving the data and preparing for the next trail.

Participants in the intervention group then spent a two-week period of familiarization with the intervention protocol exercises by watching pre-recorded videos. Weeks four through nine were the period for intervention. Participants in the intervention group performed the sixty-minute intervention protocol twice a week, delivered through one asynchronous and one synchronous classes per week using ZOOM (San Jose, California) and pre-recorded footage. The pre-recorded footage the intervention group received was the same protocol they performed at the beginning of the week. The intervention protocol included a warm-up, conditioning exercises, and a cool down. One new exercise was added weekly into the protocol building off the exercises learned in the two-week familiarization period. The series addressed progressive overloaded to provide a challenge consistent with the number of weeks that they were in training. Each participant in the intervention group met in Messick Theater Arts Building Room 115 for the synchronous class on Monday's at 4pm, and they were in their own space performing the intervention protocol for the asynchronous class. Within the live session, the instructor demonstrated each of the exercises and gave general feedback but did not give individual corrections. Participants were required to show proof of completion through sending a screenshot of heart rate monitor data or smart watch data to the PI at the end of each week. Both sessions were recorded through a heart rate monitor device or smart watch and submitted to the PI with a time stamp to ensure accurate completion.

Participants in the control group did not participate in a formal training class; they performed their own form of supplemental training. The training consisted of self-selected anaerobic exercise, strength training, aerobic exercises, and/or yoga classes. They were required to participate in their own form of training twice a week lasting 40-60 minutes each, to replicate the training requirements of the intervention group. To ensure participants in the control group were participating in their own supplemental training workouts ,they were asked to take record their training with a heart rate monitor device or smart watch and provide the PI with a screenshot including the time stamp each week. During the intervention, participants went on with normal dance technique courses, performance rehearsals, and performances.

Over the six-week intervention period compliance from the intervention group was 99.3%, with only one session missed by a single participant, and 98.6% for the control group with only one session missed by two participants.

Data Reduction

Once the data was collected the markers were labeled in QTM and gap filled to have all marker data be equal or higher than 90% fill for all phrases. The QTM file was then exported to a .c3d file to work in Visual 3D. In V3D a 7-segment model was created to view the kinematics of the pelvis, right and left thighs, right and left shanks, and right and left feet. Events were labeled for each participants trials by hand for the right side and left side of each movement phrase. Sagittal pelvic angle in degrees was evaluated at these events using a pipeline command referencing the lab to the pelvic angular position. Each event references a specific dance movement before, during, or after a set of other movements. These events are listed as:

For Ballet 1: Start Position, First Position 1, First Position 2, Grand Plié First, Fifth Position Back, Fifth Position Front, and Grand Plié Fifth.

For Ballet 2: Fifth Position Front 1, 2, and 3, as well as Fifth Position Back 1, 2, and 3.

For Modern: Start Position 1 and 2, Passe 1 and 2, Parallel Attitude Back 1 and 2, Pénche 1 and 2, and Passe 3 and 4.

Each EMG waveform was rectified to convert all values to positive numbers and digitally filtered with a high pass filter at 10Hz and a low pass filter at 25Hz. The high pass filter removed low frequency vibrations of the electrodes which are typically caused by movements of the muscle bellies. The low pass filter removed the high frequency content of the signal to produce a relatively smooth EMG signal. The resultant linear envelope was used to ensure that the data was smoothed of noise and all EMG values were positive. All EMG values were normalized per participant with their maximum voluntary isometric contraction of each muscle group. The mean EMG for each muscle over the entire movement phrase was calculated for each trail.

Pelvic alignment was assessed as the angular position of sagittal pelvic tilt at each event listed above for each movement phrase. The amount of degree change is not specifically important in this study, but a decrease in sagittal pelvic tilt is considered an improvement.

Statistical Analysis

Repeated measures 2 x 2 ANOVAs with factors of group by time were used to compare sagittal pelvic alignment of the intervention group and the control group by pre-test and post-test ($P<0.05$). Statistical analysis was done to look for an interaction effect between groups at the various levels of pre and post intervention (IBM SPSS Statistics, Chicago, Illinois). Upon completion of the statistical analysis one participant was excluded from the kinematic analysis and 2 participants were excluded from the EMG analysis. The data collected for these individuals was 3.3 to 4.0 standard deviations away from the average of the groups.

Chapter IV: Results

Introduction

The purpose of the study was to compare the effects of online dance-specific supplemental training versus the control group on pelvic alignment changes and lower-extremity muscle activation in university level dancers. It was hypothesized that dancers who receive online supplemental training as a dance-specific conditioning intervention will have improved pelvic alignment and lower-extremity muscle activation compared to dancers in the control group participating in an active self-selected fitness routine. Repeated Measures 2 x 2 ANOVAs with factors of group by time were used to compare sagittal pelvic alignment of the intervention group and the control group by pre-test and post-test.

This chapter is partitioned into the following results sections: Intervention verses Control of Pelvic alignment in ballet, Intervention verses Control of Pelvic alignment in modern, Intervention verses Control of Muscle activation in ballet, Intervention verses Control of Muscle activation in modern, and a summary.

Intervention verses Control of Pelvic Alignment in Ballet

In ballet phrase 1, the degree of sagittal pelvic alignment was evaluated at first position 1 in the movement phrase, averages and standard deviation were calculated (Table 1). There was no statistically significant interaction effect during ballet 1. There were also no statistically significant interactions in the time effects (pre vs post) and group effects (intervention vs control). Sagittal pelvic alignment averages of groups pre- versus post-test were analyzed for the right side and the left side (Figure 1). While there was a noticed decrease from the intervention group in the sagittal pelvic angle on the right side of ballet 1 at first position 1, the comparison of the increase shown in the control group was not enough to provide data of statistical significance.

Ballet 1						Interaction Effect		Within Group Effects		Between Group Effects	
Group	**Movement**	**Side**	**Time**	**Average**	**Standard Deviation**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**
Intervention	First 1	Right	Pre	-12.4	3.3	0.717	0.407	0.004	0.950	0.262	0.614
			Post	-11.8	4.4						
Control			Pre	-12.5	3.3						
			Post	-13.2	4.5						
Intervention	First 1	Left	Pre	-11.7	4.0	0.081	0.779	0.021	0.885	0.475	0.498
			Post	-12.0	4.2						
Control			Pre	-12.9	3.8						
			Post	-12.8	3.9						

Table 1: Comparison of Sagittal Pelvic Alignment for Ballet 1
Mean and standard deviation values of sagittal pelvic alignment in degrees in the control group and intervention group for Ballet phrase 1 listed by pre-test and post-test. P-values are **bolded** to show significant differences.

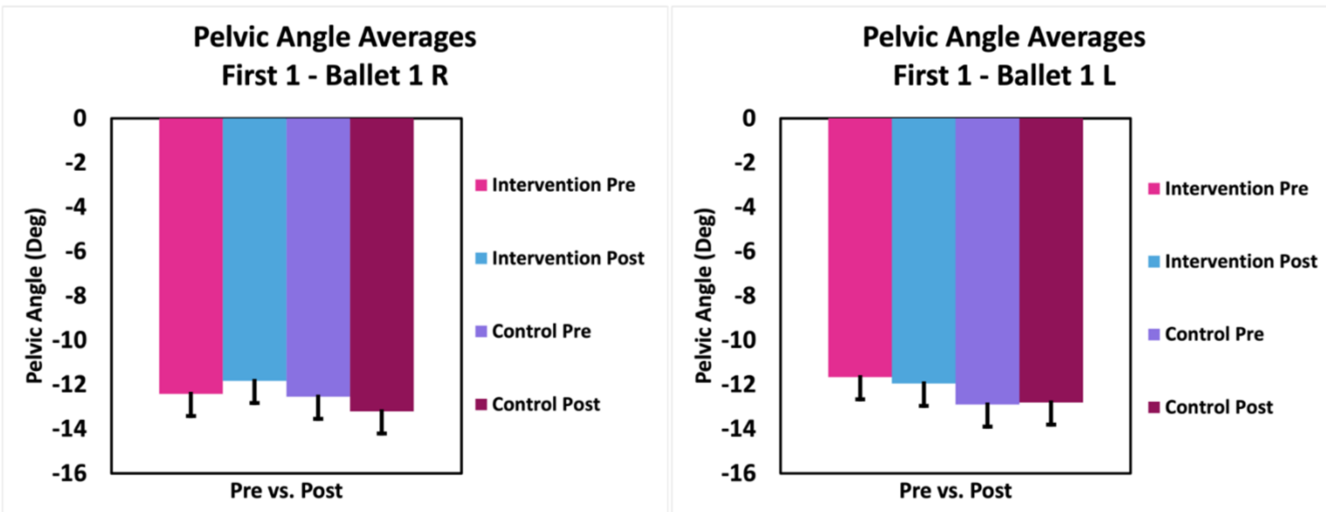

Figure 1: Sagittal Pelvic Angle Averages Ballet 1
The sagittal pelvic alignment averages on the right and left side by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found for ballet 1 in first position 1.

In ballet phrase 2, the degree of sagittal pelvic alignment was evaluated at fifth position back in the movement phrase (Table 2). There was a significant interaction effect during fifth position back on the right side between the intervention group and control group (p-value = 0.048). The intervention group decreased the average sagittal pelvic alignment (Mean difference = -2.453) in fifth back (p-value = 0.041), while the control group remained statistically unchanged (Mean Difference = 0.975, p-value = 0.418). Simple main effects show that the intervention group showed statistical significance in fifth position back on the right side of ballet 2 (p-value = 0.041) compared to the control group (Table 3). Side by side comparison of individual participants sagittal pelvic alignment pre-test versus post-test on the right side (Figure 2) shows a decrease in sagittal pelvic alignment for the intervention group in ballet 2 while the control group did not show a decrease.

Ballet 2						Interaction Effect		Pairwise Comparison	
Group	Movement	Side	Time	Average	Standard Deviation	F Ratio	Significance Level	Mean Difference	Significance Level
Intervention	Fifth Back	Right	Pre	-18.0	4.2	**4.405***	**0.048****	**-2.453***	**0.041****
			Post	-15.6	3.5				
Control			Pre	-15.7	4.2			0.975	0.418
			Post	-16.6	3.5				
Intervention	Fifth Back	Left	Pre	-18.0	3.9	2.453	.132	-1.263	0.270
			Post	-16.7	3.5				
Control			Pre	-14.4	3.7			1.263	0.291
			Post	-15.6	3.7				

Table 2: Comparison of Sagittal Pelvic Angle for Ballet 2
Mean and standard deviation values of sagittal pelvic alignment in degrees in the control group and intervention group for Ballet phrase 1 listed by pre-test and post-test. P-values are **bolded** to show significant differences. * = significant interaction, ** = P<0.05.

Intervention Pre vs Post		Control Pre vs Post	
F Ratio	Significance Level	F Ratio	Significance Level
4.718*	**0.041****	0.682	0.418

Table 3: Simple main effects for Ballet 2 Fifth Back Right
P-values are **bolded** to show significant differences. ***** = significant interaction, ****** = P<0.05.

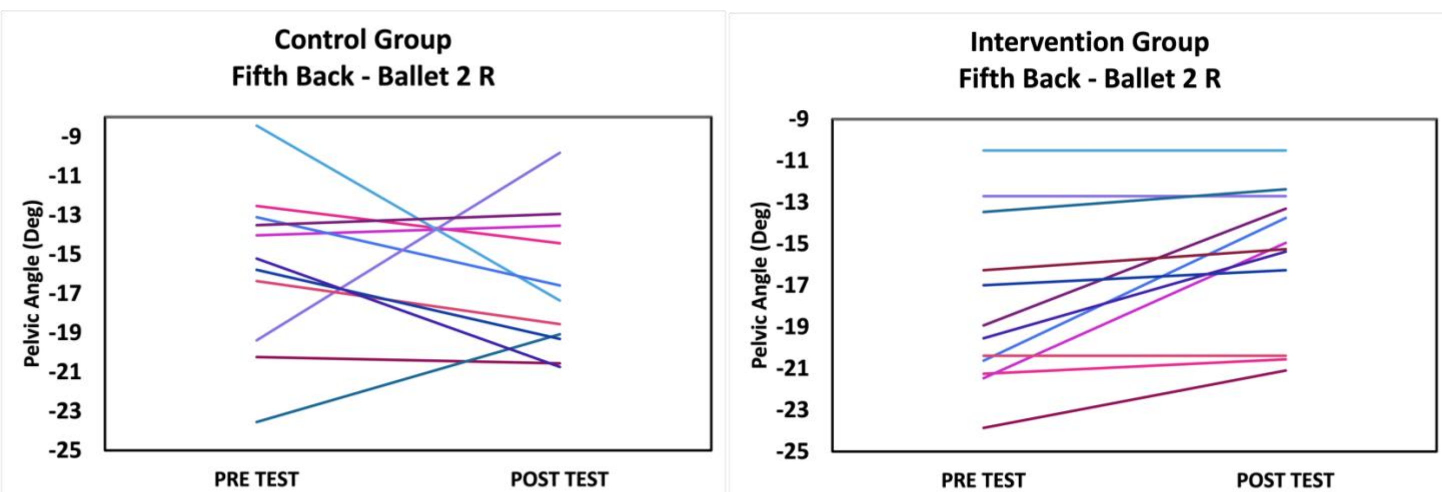

Figure 2: Comparison of Participants Ballet 2 R
Side by side comparison of individual participants sagittal pelvic alignment for pre-test and post-test on the right side. The control group decreased the average sagittal pelvic alignment from the pre-test to the post-test while the control group showed no consistent trend on the right side for ballet 2 in fifth back.

Intervention verses Control of Pelvic Alignment in Modern

In the modern phrase, the degree of sagittal pelvic alignment was evaluated at parallel attitude 1 in the movement phrase (Table 4). There were no significant interaction effects during modern. There were also no statistically significant interactions in the time effects (pre vs post) and group effects (intervention vs control). Sagittal pelvic alignment averages of groups pre- versus post-test were analyzed (Figure 3). While there was a slight decrease from the intervention group in the sagittal pelvic angle during modern in parallel attitude 1, the comparison of the increase shown in the control group was not enough to provide data of statistical significance.

Modern					Interaction Effect		Within Group Effects		Between Group Effects	
Group	**Movement**	**Time**	**Average**	**Standard Deviation**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**
Intervention	Parallel Attitude 1	Pre	-61.8	10.3	1.725	0.203	1.725	0.203	0.697	0.413
		Post	-61.0	10.4						
Control		Pre	-56.0	11.3						
		Post	-60.1	10.4						

Table 4: Comparison of Sagittal Pelvic Angle for Modern
Mean and standard deviation values of sagittal pelvic alignment in degrees in the control group and intervention group for Ballet phrase 1 listed by pre-test and post-test. P-values are **bolded** to show significant differences.

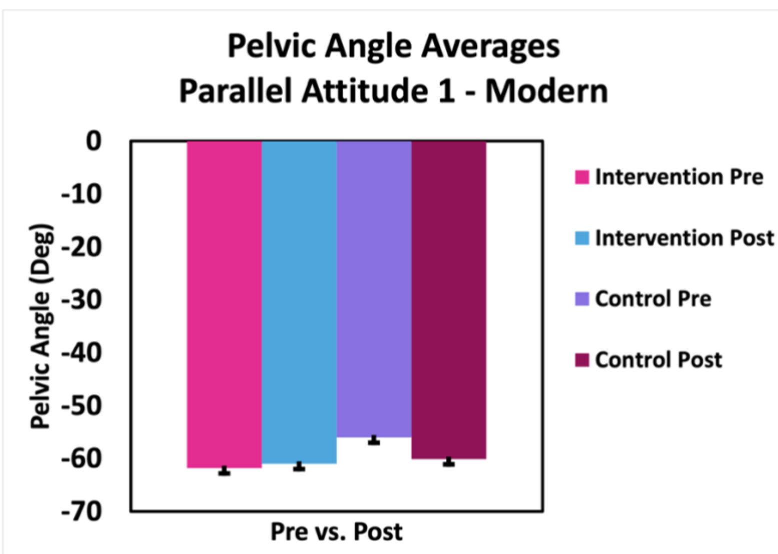

Figure 3: Sagittal Pelvic Angle Averages for Modern
The sagittal pelvic alignment averages on the right side by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found for modern in parallel attitude 1.

Intervention verses Control of Muscle Activation in Ballet

In the ballet phrase 1, the average muscle activation was evaluated for the duration of the entire movement phrase; all EMG values were normalized by participant for the erector spinae and rectus femoris (Table 5). There was no statistically significant interaction effect during ballet 1. There were also no statistically significant interactions in the time effects (pre vs post) and group effects (intervention vs control). Muscle activation averages of groups pre- versus post-test were analyzed for the erector spinae right side and the left side (Figure 4) as well as the rectus femoris right side and left side (Figure 5). As a result of high standard deviations, at both pre- and post-test, the interaction seen between the control group and intervention group was not reviewed as statistically significant.

Ballet 1						Interaction Effect		Within Group Effects		Between Group Effects	
Group	**Muscle**	**Side**	**Time**	**Average**	**Standard Deviation**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**
Intervention	Erector Spinae	Right	Pre	0.179	0.080	0.864	0.363	0.177	0.678	2.475	0.131
			Post	0.196	0.051						
Control			Pre	0.156	0.061						
			Post	0.149	0.052						
Intervention		Left	Pre	0.176	0.080	3.270	0.085	1.188	0.288	0.869	0.362
			Post	0.214	0.057						
Control			Pre	0.176	0.075						
			Post	0.167	0.053						
Intervention	Rectus Femoris	Right	Pre	0.370	0.131	0.000	0.997	0.119	0.734	2.440	0.133
			Post	0.362	0.150						
Control			Pre	0.290	0.148						
			Post	0.282	0.108						
Intervention		Left	Pre	0.538	0.424	0.201	0.137	1.998	0.172	2.387	0.172
			Post	0.452	0.226						
Control			Pre	0.363	0.212						
			Post	0.318	0.124						

Table 5: Comparison of Muscle Activation for Ballet 1
Mean and standard deviation values of muscle activation in mV in the control group and intervention group for Ballet phrase 1 listed by pre-test and post-test. P-values are **bolded** to show significant differences. ***** = significant interaction, ****** = P<0.05.

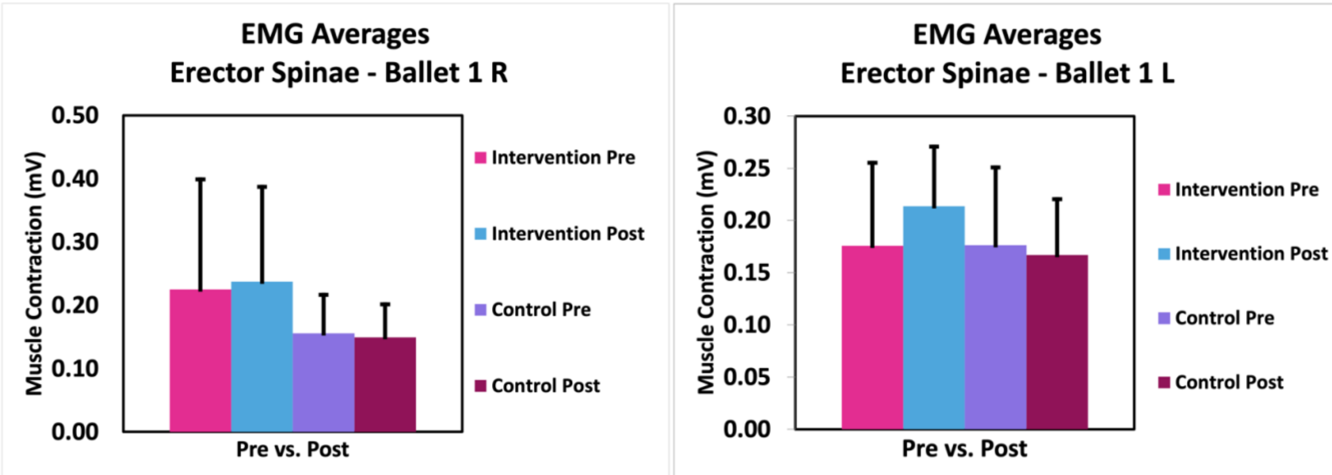

Figure 4: Erector Spinae Averages Ballet 1
The erector spinae averages on the right side by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found.

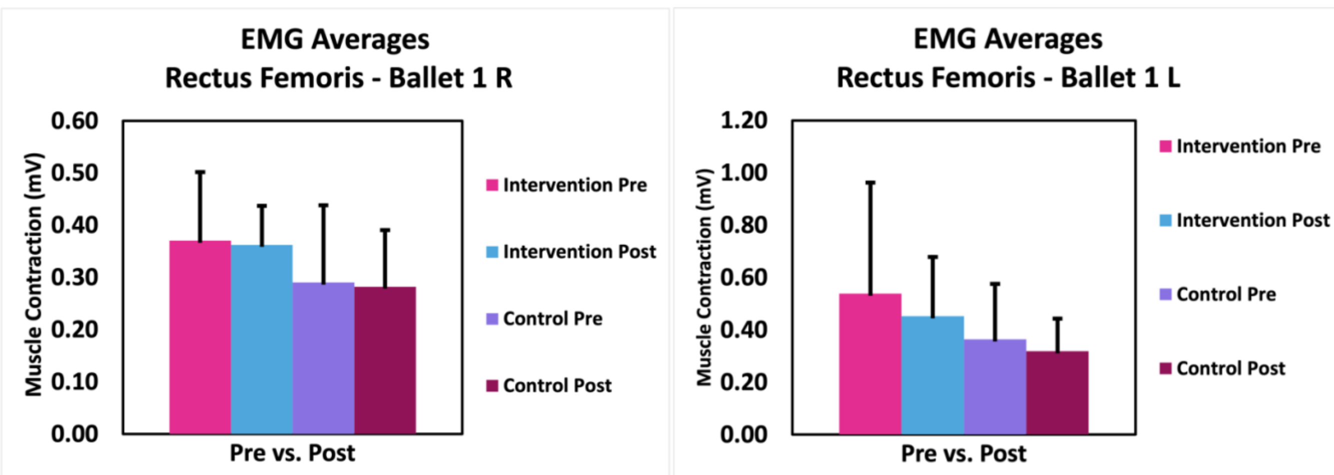

Figure 5: Rectus Femoris Averages Ballet 2
The rectus femoris averages on the right side by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found.

In the ballet phrase 2, the average muscle activation was evaluated for the duration of the entire movement phrase; all EMG values were normalized by participant for the erector spinae and rectus femoris (Table 6). There was no statistically significant interaction effect during ballet 2. There was no statistically significant interaction in the time effects; however, there was a statistically significant group effect (F ratio = 5.144 and P = 0.033). Muscle activation averages of groups pre- versus post-test were analyzed for the erector spinae for the right side and the left side (Figure 6), as well as for the rectus femoris for the right side and the left side (Figure 7).

Ballet 2						Interaction Effect		Within Group Effects		Between Group Effects	
Group	**Muscle**	**Side**	**Time**	**Average**	**Standard Deviation**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**
Intervention	Erector Spinae	Right	Pre	0.383	0.244	0.203	0.657	0.091	0.766	3.624	0.070
			Post	0.379	0.152						
Control			Pre	0.258	0.123						
			Post	0.279	0.069						
Intervention		Left	Pre	0.476	0.354	0.871	0.361	1.601	0.219	**5.144****	**0.033****
			Post	0.367	0.141						
Control			Pre	0.280	0.105						
			Post	0.264	0.084						
Intervention	Rectus Femoris	Right	Pre	0.559	0.364	0.384	0.542	0.012	0.913	3.034	0.096
			Post	0.525	0.226						
Control			Pre	0.371	0.209						
			Post	0.394	0.139						
Intervention		Left	Pre	0.457	0.359	0.176	0.679	0.098	0.757	1.734	0.201
			Post	0.460	0.285						
Control			Pre	0.335	0.203						
			Post	0.313	0.145						

Table 6: Comparison of Muscle Activation for Ballet 2
Mean and standard deviation values of muscle activation in mV in the control group and intervention group for Ballet phrase 2 listed by pre-test and post-test. P-values are **bolded** to show significant differences. * = significant interaction, ** = P<0.05.

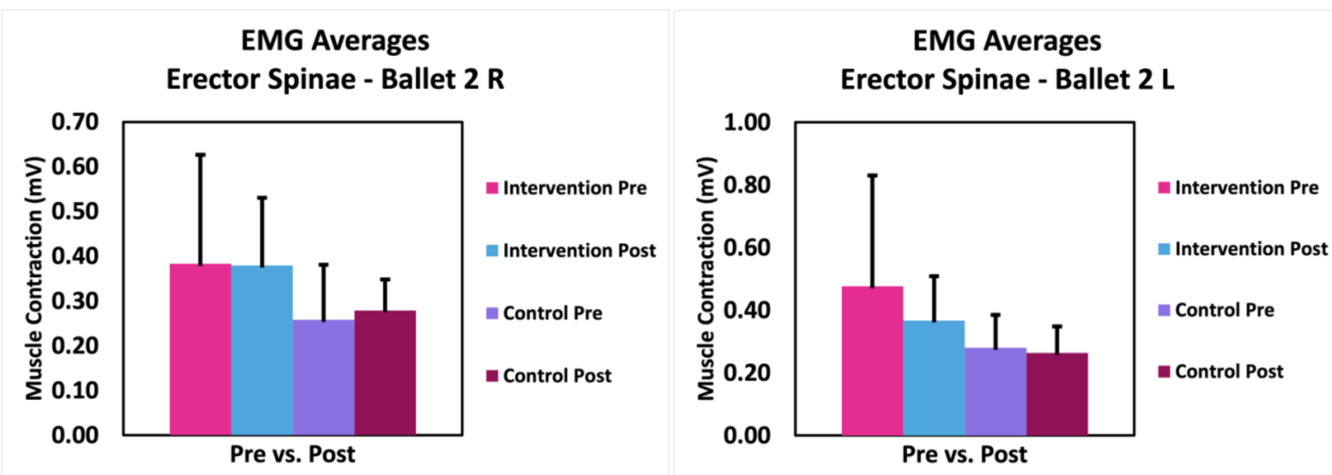

Figure 6: Erector Spinae Averages Ballet 2
The erector spinae averages on the right side by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found.

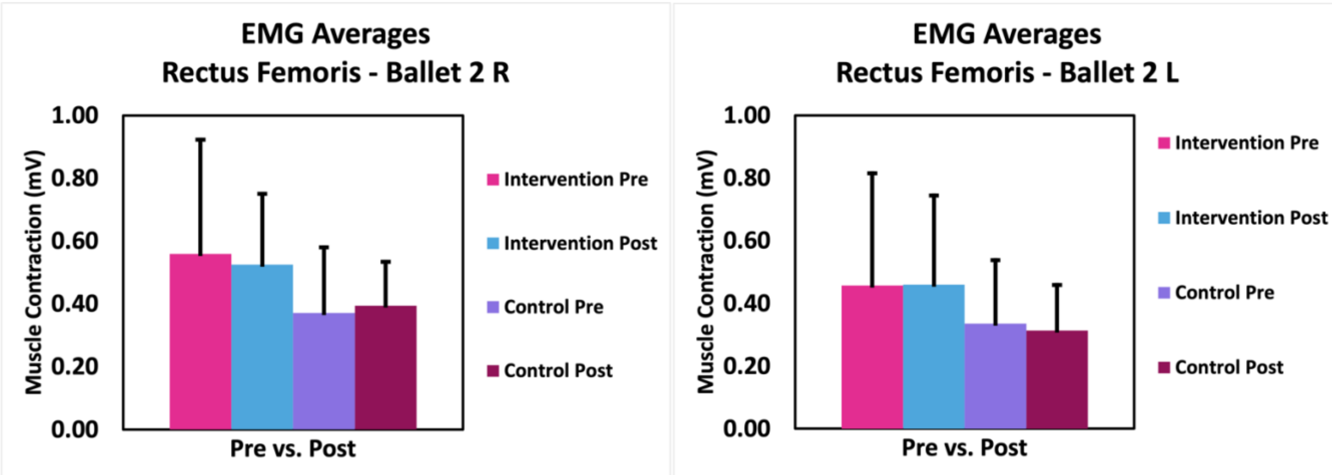

Figure 7: Rectus Femoris Averages Ballet 2
The rectus femoris averages on the right side by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found.

Intervention verses Control of Muscle Activation in Modern

In the modern phrase, the average muscle activation was evaluated for the duration of the entire movement phrase; all EMG values were normalized by participant for the erector spinae and rectus femoris (Table 7). There was no significant interaction effect during modern. There were also no statistically significant interactions in the time effects (pre vs post) and group effects (intervention vs control). Muscle activation averages of groups pre- versus post-test were analyzed for the erector spinae (Figure 8) and the rectus femoris (Figure 9). As a result of high standard deviations, at both pre- and post-test, the interaction seen between the control group and intervention group was not reviewed as statistically significant.

Modern					Interaction Effect		Within Group Effects		Between Group Effects	
Group	**Muscle**	**Time**	**Average**	**Standard Deviation**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**	**F Ratio**	**Significance Level**
Intervention	Erector Spinae	Pre	0.710	0.385	2.060	0.165	0.055	0.817	0.450	0.509
		Post	0.571	0.233						
Control		Pre	0.451	0.319						
		Post	0.644	0.688						
Intervention	Rectus Femoris	Pre	0.776	0.307	0.000	0.994	0.273	0.607	3.692	0.068
		Post	0.803	0.335						
Control		Pre	0.560	0.250						
		Post	0.803	0.335						

Table 7: Comparison of Muscle Activation for Modern
Mean and standard deviation values of muscle activation in mV in the control group and intervention group for Ballet phrase 2 listed by pre-test and post-test. P-values are **bolded** to show significant differences.

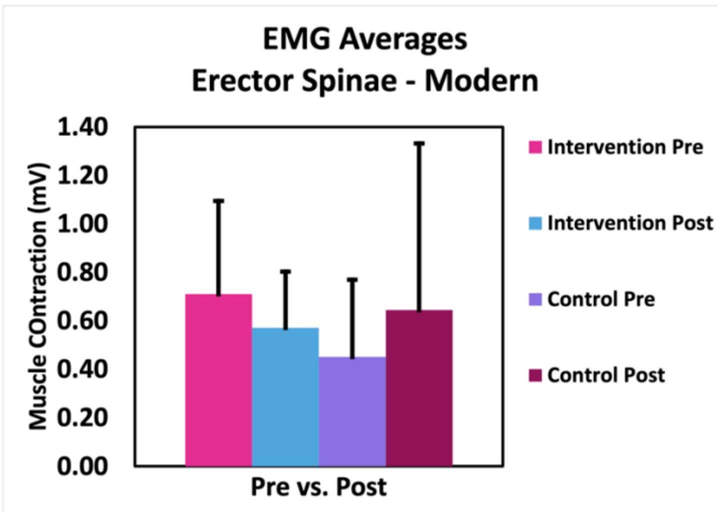

Figure 8: Erector Spinae Averages Modern
The erector spinae averages by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found.

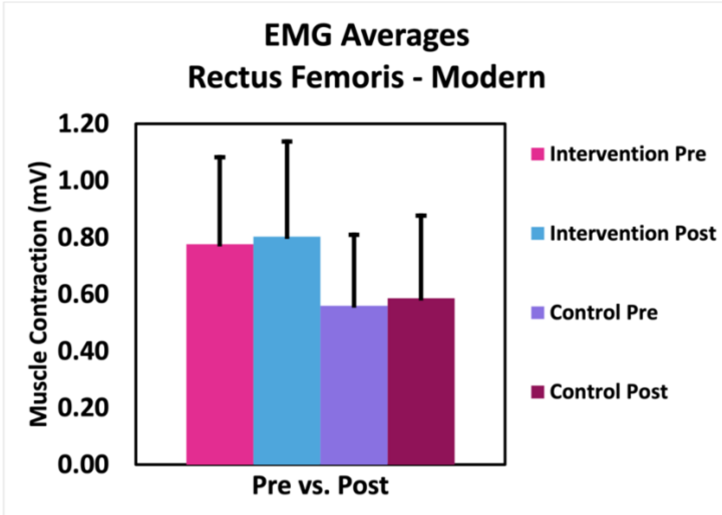

Figure 9: Rectus Femoris Averages Modern
The rectus femoris averages by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. No significant interaction was found.

Summary

Compared to the control group, the intervention group displayed two points of significance. One interaction effect in ballet phrase 2 on the right side, decreasing the sagittal pelvic angle, and one between groups effect for the erector spinae in ballet phrase 2 on the left side. Overall, this showed that there was little statistically significant difference between the intervention group and control group other than these two points of interest. This indicates that the dance specific intervention did not have a major influence in decreasing sagittal pelvic alignment and influencing lower-extremity muscle activation. Based on these results, we reject our original hypothesis that dancers who receive online supplemental training as a dance-specific conditioning intervention will have improved pelvic alignment and lower-extremity muscle activation compared to dancers in the control group participating in an active self-selected fitness routine.

Chapter V: Discussion

Introduction

The purpose of the study was to compare the effects of online dance-specific supplemental training versus the control group on pelvic alignment changes and lower-extremity muscle activation in university level dancers. It was hypothesized that dancers who receive online supplemental training as a dance-specific conditioning intervention will have improved pelvic alignment and lower-extremity muscle activation compared to dancers in the control group participating in an active self-selected fitness routine. This chapter is divided into the sections: Success of traditional training on dancers, Dance-specific conditioning protocols, Online versus in-person training, Delimitations, and a Conclusion.

Success Of Traditional Training on Dancers

Previous studies have examined conditioning protocols or supplemental training for dancers in various areas of dance performance such as, jump height, anaerobic fitness, aerobic fitness, and strength. These studies used traditional methods of conditioning individually such as, weightlifting, cardiovascular training, Pilates and plyometrics (Wyon 2012, Kozai 2012). Dancers in the control group, of our study, had the option to choose what style of training to perform. They used traditional modalities of conditioning, similar to studies by Twitchet et al. (2011) and Angoi et al. (2009), specifically with aerobic exercise as a main form of supplemental training. Butulis et al. (2021) showed that dancers can improve cardiovascular fitness, muscle endurance, and lower extremity power with body-weight-only exercise in 4 to 6 weeks. Our study had a similar structure in the timeline when compared to Butulis et al. (2021). In another study, lower limb strength training was used to improve the height of a countermovement jump in dancers and successfully showed after 16 weeks of strength training the lower limbs, ballet dancers had an improved jump height from the supplemental training program (Ávila-Carvalho et al. 2022).

These studies have shown how adaptable and trainable dancers are and similar to athletes of other sports and professions in this regard. Traditional training is shown to be successful by showing improved performance or have a reduced number of injury days. Our study did not investigate injuries during and after the intervention was concluded, more follow up with the dancers is needed to assess this factor. Rodrigues-Krause et al. (2013) looked at VO_2 max of dancers in class and during a performance to provide information on how different the two movement requirements were. Taking into consideration the dancers performance schedule, our study limited the time of the intervention period in order to be respectful of the large demand of the dancers during a performance week.

Dance-Specific Conditioning Protocols

Few studies have been published with a protocol that is similar to our dance-specific conditioning protocol. The combination of ballet barre, yoga, Pilates, somatics, and neuromuscular training targets abdominal activation, pelvic alignment, whole body stability and strengthening, and range of motion that is important for a dancer no matter the time in their career (Smith et al. 2013, Kenny et al. 2017, Kozai 2012). We wanted to investigate the effects of a training this dance-specific to evaluate the effectiveness it had in correcting pelvic alignment. In the literature, there has been demonstrated success in improving postural stability, both static and dynamic, in girls through modern dance training (Marinkovic et al. 2021). This training, defined as 7 or more hours per week of modern dance training, allowed researchers to see improvement in the dancer's use of proprioception compared to the control group of non-dancers. Static postural stability was assessed with a force plate to observe the displacement of the center of pressure (COP). The dance group showed more stability in static postural stability (*f*= 76.78; *p*< 0.0001) than the non-dance group at the time of the assessment. While our control group was an active dance group as well, their self-selected protocol did not combine the same dance-specific modalities that the intervention group received.

Looking more into a Pilates based conditioning approach, Ahearn et al. (2018), found that dancers who participated in a Pilates based conditioning program dancers were able to improve postural alignment, flexibility, and abdominal strength. This intervention consisted of a screening for baseline measurements, 14-weeks without intervention, and 14-weeks of a Pilates based conditioning program, with three separate screening trails. This study demonstrated a significant decrease in number of postural misalignments (P<0.001) from screening II to screening III and showed the comparison of improved alignment (defined by the total number of postural misalignments) to years of dance training from screening II to screening III (p= 0.01, *p*= 0.56). Pilates is very similar to dance movement in its control and emphasis on pelvic alignment, strengthening, and improving flexibility. This study showed great success and significant results compared to our study, but the large timeframe that this study was able to achieve is not comparable to our 6-week intervention period. Our study was able to show an improvement in pelvic alignment in one position, fifth back on the right side of ballet 2 (p-value < 0.048). However, it is important to note that this study by Ahearn et al. (2018) was successful because the time of intervention was extensive.

The aforementioned studies were able to show improvement in dancers' postural stability, pelvic alignment, flexibility, and strength, yet they concluded that more research and longer follow up studies are still needed to assess the risk of injury and injury prevention measures each dance-specific conditioning protocols had on the population of these studies.

Much like our study these were able to target a more dance-specific population. Using the information in these studies we can evaluate our intervention and take into consideration the duration and exercises performed in the intervention to strengthen the protocol for studies in the future.

Online Versus In-Person Training

The studies above were successful in finding statistical significance with their training programs, we can now compare our online training with those results. Our study provided one significant interaction in sagittal pelvic alignment in Ballet 2 Fifth Back Right ($F= 4.405$, $P< 0.048$). With this interaction, the data allowed us to see a difference in pelvic alignment in this position when performing a movement to the back to this closed fifth position. In dance movement of this genre, there is a high range of variability in the amount of sagittal pelvic tilt. The protocol was specifically designed to address this change in the sagittal pelvic angle as we expected this interaction to occur.

Our study also provided information of a group effect in Ballet 2 of the Erector Spinae on the left side ($F= 5.144$, $P< 0.033$). The data showed that the intervention group had a higher muscle activation over the control group in this phrase. The protocol involved many exercises that specifically required the use of the erector spinae muscle. Given that this group effect was found on the left side of the phrase, with the EMG electrodes placed on the right side of the body, the erector spinae was recruited as a stabilizing muscle as the left leg and side of the body was working and the right leg and side of the body was the supporting limb.

In-person dance instruction typically has more physical interaction and tactile feedback between instructor and student; whereas, our study had less interaction and tactile feedback between the investigators and the participants because of the online format. Our online intervention did little to implement change in sagittal pelvic alignment in the intervention group but was not unsuccessful in providing an interaction effect in on kinematic evaluation. Our protocol may still provide the dancers with the pelvic control to support their dance technique and provide greater control over movements without major change in their pelvic alignment. Because the aesthetic nature of dance is still important, the dancer still may be able to execute dance movements that satisfy the aesthetic requirements without having major changes to the pelvic kinematics; thus, the dancer may still be able to complete the movement even though the pelvic changes were minimal. In Deckert et al. (2007) study, they used teachers' ratings as well for the comparative analysis to define the degree of pelvic tilt, so the students may have begun in an acceptable range of pelvic tilt; thus, major changes wouldn't have occurred anyway. In the age of the COVID-19 pandemic many classes have shifted to online instruction due to state and country guidelines and regulations. This has impacted the way classes are taught and performed at home by students, as well as lowered the amount of physical activity done at home (Puccinelli et al. 2021). This survey was done online after the pandemic began and assessed physical activity and mood state disorders.

In a positive form of online instruction, Bruyneel et al. 2020 performed an evaluation on instruction during the height of the pandemic, i.e., 2020-2021 for dancers in the Lyon National Conservatory of Music and Dance. Through this study it was found that although in-person or "in the flesh" dance classes are still preferred, the dancers and instructors were able to develop a pedological way to assess dance both online to be reused once in-person classes were able to be resumed. While this study noted that most dancers and instructors prefer in-person classes, the pandemic has been able to shed light on how instruction can be adapted and still hold the ability to maintain technique and improve social interaction even during stay-in-place orders (Bruyneel et al. 2020).

Our data provides partial support for the hypothesis, while most variables did not show a significant interaction, we did observe a significant interaction in sagittal pelvic alignment in Ballet 2 Fifth Back. The intervention group had less pelvic tilt after the intervention than the control. These results give information to the reduced risk of injury of these dancers in the intervention group with more lumbopelvic control (Kenny et al. 2017). Our study was able to show the ability to maintain sagittal pelvic alignment over a 6-week period of intervention. While a longer period of intervention might show more improvements, an in-person study is needed of the same 6-week period to see if more improvements of sagittal pelvic alignment can be made. Another way of evaluating our protocol and its effectiveness when given through an online format is to have two days of synchronous classes, rather than just one. The increased amount of live verbal and visual feedback could influence the understanding of the dancers in the intervention group.

Delimitations

For this study, time was a factor that can be improved in future studies. For this six-week intervention our data provided us with a significant interaction in sagittal pelvic alignment, while most other variables did not show a significant interaction. The present protocol was delimited to only six weeks in length and only two training sessions per week for a total of 12 intervention sessions, in order so that the intervention did not interfere with the performance schedule. This exposure may have been less that the amount necessary to elicit more substantial changes in most pelvic kinematics and muscle EMG. While other studies have seen improvement in other areas with these parameters more research is needed in a longer duration and potentially more frequent intervention, and they did not face the challenge of being in an online format. This study was set at a specific time and the groups were delimited by the availability of the participants, resulting in the control group having a different level of experience compared to the intervention group. The control group consisted of mostly first-year students, that are less experienced and have less knowledge of pelvic alignment awareness. The intervention group was mainly third-year students that have more knowledge and ability to maintain proper pelvic alignment, we are delimited to this factor. This study was delimited to its sample size of 24 participants. There were no previous data from the literature of how to determine an appropriate sample size. This intervention was delivered in an online synchronous and asynchronous format, limiting the amount of interaction between participant and instructor. This study repeated in an in-person format could yield different results given that there is a more hands on approach to instruction when face-to-face. This study was not performed in conjunction with other classes and could have been strengthened by a technique course that followed the intervention class. The technique course would reinforce what was trained during the intervention, allowing for dancers to have more understanding of the application of the intervention protocol within a dance technique class. A future study may take into consideration time of day and place the dance-specific conditioning protocol before a ballet class to test reliability and fatigue. We are delimited to our conditions selected and our data may not be comparable to other dance-specific conditioning protocols.

Conclusion

Compared to the control group, the intervention group showed one statistically significant point of improvement in ballet 2, fifth position back, and one statistically significant group effect in overall muscle contraction of the erector spinae in ballet 2. This indicates that within the contrasts of our protocol, the online dance-specific protocol had some effect in improving sagittal pelvic alignment and lower extremity muscle activation in university dancers. Based on these results, on the whole, we mostly reject our original hypothesis. The present study provided only partial support for the adoption of online training for the specific issues we investigated: pelvic kinematics and selected muscle EMG in ballet and modern dance. Due to the limitations a larger and longer study with more exposure time may be needed to assess online training more accurately for these variables.

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Appendix A: Med Par Q

MODIFIED MEDICAL PAR-Q

Please read the following carefully and answer as accurately as possible.

	Yes	No
1. Have you ever suffered from low blood pressure?	……	……
2. Have you ever been prescribed a long-term course of steroids or anything to thin your blood?	……	……
3. Has your doctor ever said you have heart trouble?	……	……
4. Do you suffer frequently from chest pains?	……	……
5. Do you often feel faint or have dizzy spells?	……	……
6. Has a doctor ever said you have epilepsy?	……	……
7. Has a doctor ever said you have high blood pressure?	……	……
8. Has a doctor ever said you have diabetes?	……	……
9. Has a doctor ever said you have asthma?	……	……
10. Do you have a bone, joint or muscular problem which may be aggravated by exercise?	……	……
11. Do you have any form of injury?	……	……
12. Are you currently taking any prescription medications?	……	……
13. Have you suffered from a viral illness in the last 2 weeks?	……	……
14. Are you pregnant?	……	……

15. Is there anything in your current or past medical history that you have not mentioned so far on this questionnaire (conditions, diseases, orthopedic injury)? Please give details:

____

____

____

	YES	NO
Have you eaten within the last hour?		
Have you consumed alcohol within the last 24 hours?		
Have you performed exhaustive exercise within the last 48 hours?		

Appendix B: Approved Consent Form

East Carolina

University

Informed Consent to Participate in Research

Information to consider before taking part in research that has no more than minimal risk.

Title of Research Study: Identifying the effectiveness of an online dance-specific protocol on alignment and muscle activation in university dance majors
Principal Investigator: Megan Shepherd
Institution/Department or Division: Department of Kinesiology
Address: 332 Ward Sports Medicine Building, East Carolina University
Telephone #: 919-818-2920

Study Sponsor/Funding Source: None

Researchers at East Carolina University (ECU) study problems in society, health problems, environmental problems, behavior problems and the human condition. Our goal is to try to find ways to improve the lives of you and others. To do this, we need the help of volunteers who are willing to take part in research.

Why is this research being done?

The purpose of this research is to identify the effectiveness of an online dance-specific conditioning protocol on alignment and lower extremity muscle activation in university dance majors. By doing this research, we hope to learn whether or not an online dance-specific conditioning protocol is an effective way to improve pelvic alignment and look at differences in lower extremity muscle activation in university dance majors.

Why am I being invited to take part in this research?

You are being invited to take part in this research because you meet the inclusion criteria and have no apparent contraindication to participating in the study. Inclusion criteria for participants are: healthy, over the age of 18, a dance major at East Carolina and enrolled in normal dance technique courses. If you volunteer to take part in this research, you will be one of about 30 people to do so.

Are there reasons I should not take part in this research?

I understand I should not volunteer for this study if I have a present or persistent injury that will limit my participation, am currently pregnant, am under the age of 18, have an infectious disease, have a history of an orthopedic disease, have not passed the audition to become a dance major at East Carolina University and am not enrolled as a dance major. The exclusion criterion is intended for ensured safety of the participants and is derived from other fitness intervention procedures.

What other choices do I have if I do not take part in this research?

You can choose not to participate.

Where is the research going to take place and how long will it last?

The research procedures will be conducted in the Biomechanics Laboratory, room 332 Ward Sports Medicine Building at ECU, in Messick Dance Studios, and your own space via ZOOM. Your exact schedule is dependent upon whether you participate in the control group or the intervention group and is outlined below. You will be assigned to one of the two groups and notified by the PI, Megan Shepherd as to what group you will be in.

The schedule is as follows for the control group: 1 initial 2D alignment assessment session in Messick Dance Studios (1-2 hours), 1 initial 3D alignment session and EMG muscle activity session in the Biomechanics Lab (1 hour), 8 - 12 exercise sessions of your choosing over 4 - 6 weeks (40-60 minutes each, twice a week), 1 final 2D alignment assessment session in Messick Dance Studios (1-2 hours), 1 final 3D alignment session and EMG muscle activity session in the Biomechanics Lab (1 hour).

The schedule is as follows for the intervention group: 1 initial 2D alignment assessment session in Messick Dance Studios (1-2 hours), 1 initial 3D alignment session and EMG muscle activity session in the Biomechanics Lab (1 hour), 8 - 12 dance-specific conditioning sessions over 4 - 6 weeks (40-60 minutes each, twice a week), 1 final 2D alignment assessment session in Messick Dance Studios (1-2 hours), 1 final 3D alignment session and EMG muscle activity session in the Biomechanics Lab (1 hour).

What will I be asked to do?
You are being asked to do the following:
All participants must wear black leotards and black tights to all assessment sessions. Those that have been assigned to be in the control group will only participate the Studio assessment below. Those that have been assigned to the intervention group will participate in the Studio assessment below as well as follow a dance-specific conditioning intervention protocol between the first and last weeks of the study.

During the first visit to the Studio, you will:
Provide personal information about my general health and my general movement capabilities.
Have my height/weight measured.
Complete a questionnaire about my general health and activities.
Participate in a 2D postural assessment with the understanding that photographs will be taken, which involves standing in dance and non-dance positions.
Participate in a 2D dance-specific pelvic alignment test, which involves standing in dance and non-dance positions. This assessment will require markers to be placed on bony landmarks on your pelvis and lower limbs, to be photographed and analyzed to assess pelvic tilt in degrees.

During the first visit to the Lab, you will:
Participate in a 3D motion capture and EMG muscle activation analysis that will involve being video recorded involving standard ballet barre movements and athletic modern movements.

If you have been assigned to be part of the control group, you will be required to attend a 1- 2-hour alignment assessment and EMG muscle activation protocol during the first week of the study and the last week of the study. The control group will complete a questionnaire about my general health and activities. The control group will also be responsible for recording and documenting two workouts of your choosing each week to the PI. These recordings can be a screen capture of your workout summary or a time-lapse video of the workout.

If you have been assigned to be part of the intervention group, you will be required to attend a 1-2-hour alignment assessment and EMG muscle activation protocol during the first week of the study and the last week of the study. The intervention group will complete a questionnaire about my general health and activities. The intervention group will take part in the dance-specific conditioning protocol on ZOOM two times per week for a minimum of 8 weeks and a maximum of 12 weeks:
Online Dance-Specific Conditioning - During the weeks of training, you will perform a supine, prone, side-lying, kneeling, and standing alignment exercise series designed for dancers that will be guided by a certified instructor. You will perform the progressive exercise series for 40 minutes entirety of training.

Each group will participate in all tests from the first visit once again in the final week of the study.
What possible harms or discomforts might I experience if I take part in the research?
As with any strong effort or working out, there is a possibility for muscle strain to occur. A thorough familiarization with the exercise series will minimize the risks for muscle strain and soreness. All efforts will be done below-maximal intensity, posing minimal risks for any healthy adults who meet the inclusion criteria. You will be supervised during all training and testing sessions by experienced and courteous researchers.

What are the possible benefits I may experience from taking part in this research?
This research might help us learn if an online dance-specific conditioning exercises is an effective way to improve alignment in university dance majors.

Will I be paid for taking part in this research?
We will not pay you for the time you volunteer while being in this study.

What will it cost me to take part in this research?
It will not cost you any money to be part of the research. The sponsor of this research will pay the costs of: a) the equipment used in the 3-D motion capture analysis and EMG electrodes b) the time of the graduate research assistant.
Who will know that I took part in this research and learn personal information about me?
To do this research, ECU and the people and organizations listed below may know that you took part in this research and may see information about you that is normally kept private. With your permission, these people may use your private information to do this research:
Megan Shepherd, the main investigator; Teal Darkenwald, Dance and Biomechanics Professor; Blake Jones, the graduate research assistant; and Elizabeth Bailey, the undergraduate research assistant.
Any agency of the federal, state, or local government that regulates human research. This includes the Department of Health and Human Services (DHHS), the North Carolina Department of Health, and the Office for Human Research Protections.

The University & Medical Center Institutional Review Board (UMCIRB) and its staff, who have responsibility for overseeing your welfare during this research, and other ECU staff who oversee this research.

How will you keep the information you collect about me secure? How long will you keep it?
Data files will be kept for 3 years after the study is completed. The investigators will keep my personal data in strict confidence by having my data coded. Instead of my name, I will be identified in the data records with an identity number. My name and code number will not be identified in any subsequent report or publication. The main investigators and the research students will be the only persons who know the code associated with my name and this code as well as my data will be kept in strict confidence. The computer file that matches my name with the ID number will be encrypted and the main investigators will be the only staff that knows the password to this file. The data will be used for research purposes only. This research may be utilized for future studies but at no risk of personal identifying information being released.

What if I decide I do not want to continue in this research?
If you decide you no longer want to be in this research after it has already started, you may stop at any time. You will not be penalized or criticized for stopping. You will not lose any benefits that you should normally receive.

Who should I contact if I have questions?
The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator, Megan Shepherd, at 919.818.2920 (workdays, between 8 am to 4 pm).

If you have questions about your rights as someone taking part in research, you may call the University & Medical Center Institutional Review Board (UMCIRB) at phone number 252-744-2914 (days, 8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director for Human Research Protections, at 252-744-2914.

The Principal Investigator, Megan Shepherd, is a graduate student in Kinesiology with a Biomechanics and Motor Control concentration and holds a BFA in Dance from East Carolina University.

Is there anything else I should know?
The decision to take part in this research is entirely up to you. Neither the outcome of the study or participation in the study will impact your standing in the dance program.

Identifiers might be removed from the identifiable private information or identifiable biospecimens and, after such removal, the information or biospecimens could be used for future research studies or distributed to another investigator for future research studies without additional informed consent from you or your Legally Authorized Representative (LAR). However, there still may be a chance that someone could figure out the information is about you.

I have decided I want to take part in this research. What should I do now?

The person obtaining informed consent will ask you to read the following and if you agree, you should sign this form:

I have read (or had read to me) all of the above information.
I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
I know that I can stop taking part in this study at any time.
By signing this informed consent form, I am not giving up any of my rights.
I have been given a copy of this consent document, and it is mine to keep.

____

Participant's Name (PRINT) Signature Date

Person Obtaining Informed Consent: I have conducted the initial informed consent process. I have orally reviewed the contents of the consent document with the person who has signed above, and answered all of the person's questions about the research.

____

Person Obtaining Consent (PRINT) Signature Date

Appendix C: Institutional Review Board Approval

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **rede.ecu.edu/umcirb**/

Notification of Initial Approval: Expedited

From: Biomedical IRB
To: Megan Shepherd
CC: Paul DeVita
Date: 6/23/2021
Re: UMCIRB 21-000130
Online dance training, alignment and muscle activation in university dance majors

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) occurred on 6/22/2021. The research study is eligible for review under expedited category # 4,6,7. The Chairperson (or designee) deemed this study no more than minimal risk.

As the Principal Investigator you are explicitly responsible for the conduct of all aspects of this study and must adhere to all reporting requirements for the study. Your responsibilities include but are not limited to:

1. Ensuring changes to the approved research (including the UMCIRB approved consent document) are initiated only after UMCIRB review and approval except when necessary to eliminate an apparent immediate hazard to the participant. All changes (e.g., a change in procedure, number of participants, personnel, study locations, new recruitment materials, study instruments, etc.) must be prospectively reviewed and approved by the UMCIRB before they are implemented;

2. Where informed consent has not been waived by the UMCIRB, ensuring that only valid versions of the UMCIRB approved, date-stamped informed consent document(s) are used for obtaining informed consent (consent documents with the IRB approval date stamp are found under the Documents tab in the ePIRATE study workspace);

3. Promptly reporting to the UMCIRB all unanticipated problems involving risks to participants and others;

4. Submission of a final report application to the UMICRB prior to the expected end date provided in the IRB application in order to document human research activity has ended and to provide a timepoint in which to base document retention; and

5. Submission of an amendment to extend the expected end date if the study is not expected to be completed by that date. The amendment should be submitted 30 days prior to the UMCIRB approved expected end date or as soon as the Investigator is aware that the study will not be completed by that date.

The approval includes the following items:

Name	Description
Informed Consent	Consent Forms
Medical Questionnaire	Surveys and Questionnaires
Protocol	Study Protocol or Grant Application
Recruitment Email Script	Recruitment Documents/Scripts
Social Validity Questionnaire	Surveys and Questionnaires

For research studies where a waiver or alteration of HIPAA Authorization has been approved, the IRB states that each of the waiver criteria in 45 CFR 164.512(i)(1)(i)(A) and (2)(i) through (v) have been met. Additionally, the elements of PHI to be collected as described in items 1 and 2 of the Application for Waiver of Authorization have been determined to be the minimal necessary for the specified research.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418

Appendix D: Social Validity Questionnaire

Dancer's Social Validity Questionnaire **Dancer # ________**

Please circle a number to indicate your rating & add any comments that may clarify your ratings.

1. How important do you believe it is for dancers to have good alignment at the pelvis and lower back?

   Extremely important 7 6 5 4 3 2 1 Not important at all

   Comments?

2. Do you believe the training methods used were appropriate to the purpose of improving alignment at the pelvis and lower back?

   Very appropriate 7 6 5 4 3 2 1 Very inappropriate

   Comments?

3. Please rate any changes in your alignment at the pelvis and lower back over the past ____ weeks.

   Improved a lot 7 6 5 4 3 2 1 Deteriorated a lot

   To what do your attribute any changes you observed?

4. Do you feel the benefits of the pelvic and lower back alignment training program were worth the time and effort required to complete it?

   Could not have used my time more productively 7 6 5 4 3 2 1 Wasted my time

   Comments?

5. How important do you believe it is for dancers to have good alignment in the lower limb?

   Extremely important 7 6 5 4 3 2 1 Not important at all

   Comments?

6. Do you believe the training methods used were appropriate to the purpose of improving alignment in the lower limb?

   Very appropriate 7 6 5 4 3 2 1 Very inappropriate

Comments?

7. Please rate any changes in your alignment to your lower limb over the past ____ weeks.

   Improved a lot 7 6 5 4 3 2 1 Deteriorated a lot

   To what do your attribute any changes you observed?

8. Do you feel the benefits of the lower limb alignment training program were worth the time and effort required to complete it?

   Could not have used my time more productively 7 6 5 4 3 2 1 Wasted my time

   Comments?

9. How important do you believe it is for dancers to have good posture?

   Extremely important 7 6 5 4 3 2 1 Not important at all

   Comments?

10. Please rate any changes in your posture over the past ____ weeks.

   Improved a lot 7 6 5 4 3 2 1 Deteriorated a lot

   To what do your attribute any changes you observed?

<u>Other</u> <u>Comments</u> <u>&</u> <u>Suggestions</u> - Continue *on back of page if you need more space.*

Appendix E: Additional Results

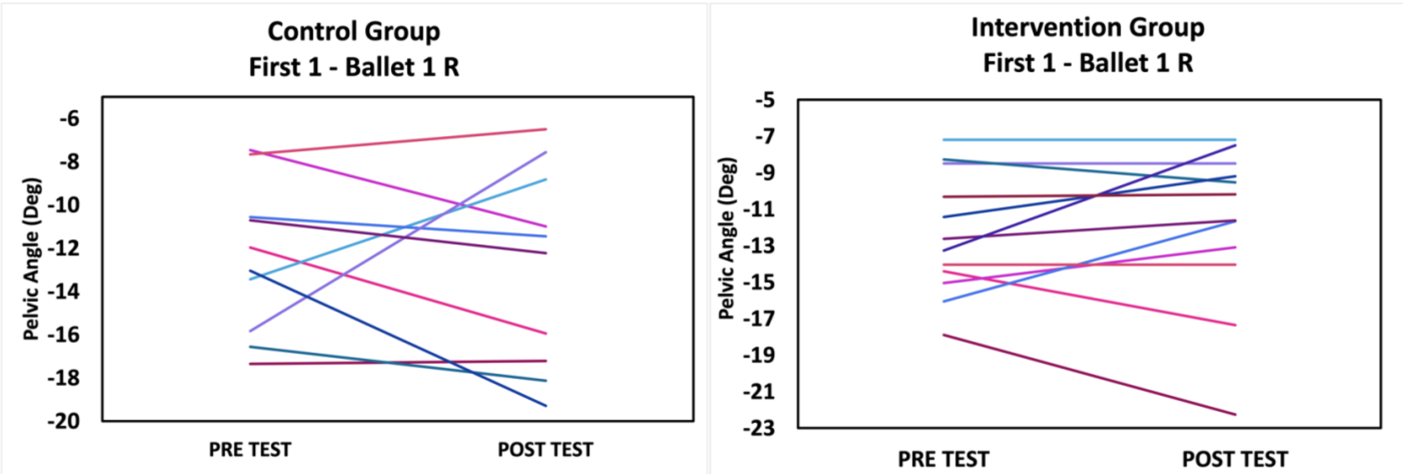

Figure 10: Comparison of Participants Ballet 1 R
Side by side comparison of individual participants sagittal pelvic alignment for pre-test and post-test on the right side. No trend to show a significant difference in group for ballet 1 in first position 1.

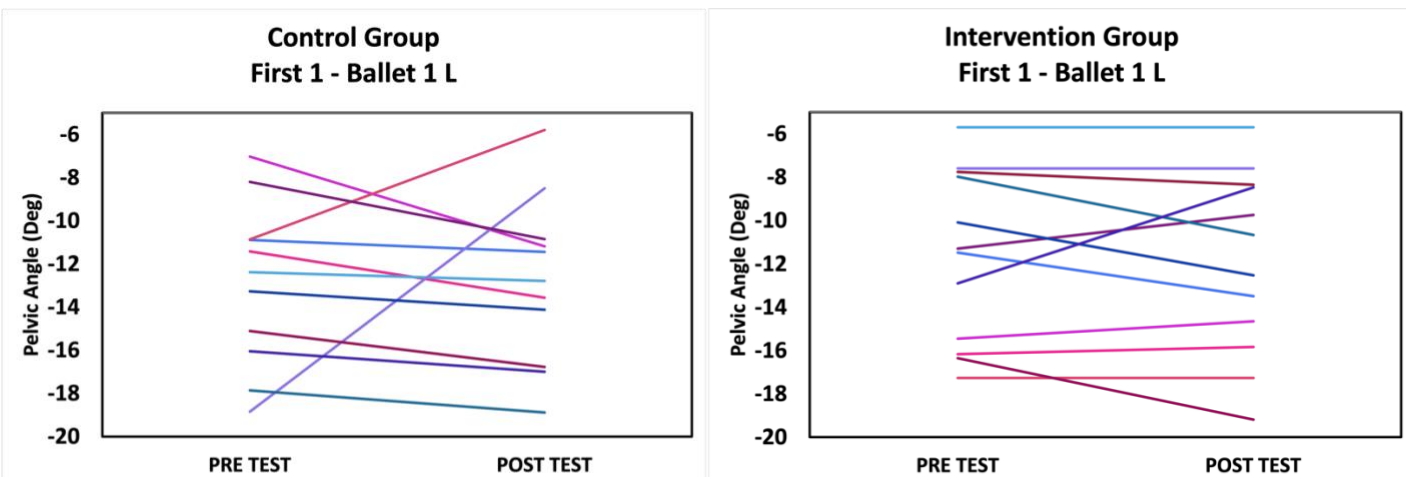

Figure 11: Comparison of Participants Ballet 1 L
Side by side comparison of individual participants sagittal pelvic alignment for pre-test and post-test on the left side. No trend to show a significant difference in group for ballet 1 in first position 1.

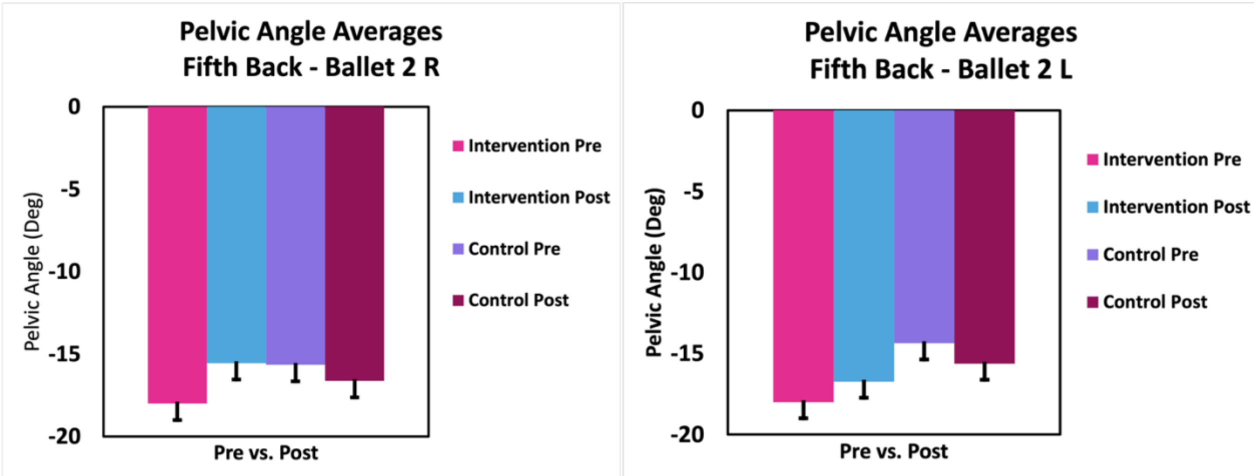

Figure 12: Sagittal Pelvic Angle Averages Ballet 2
The sagittal pelvic alignment averages on the right and left side by group for time of pre-test and post-test along with error bars of the standard deviation for each group by time. A significant interaction was found for ballet 2 in fifth back on the right side.

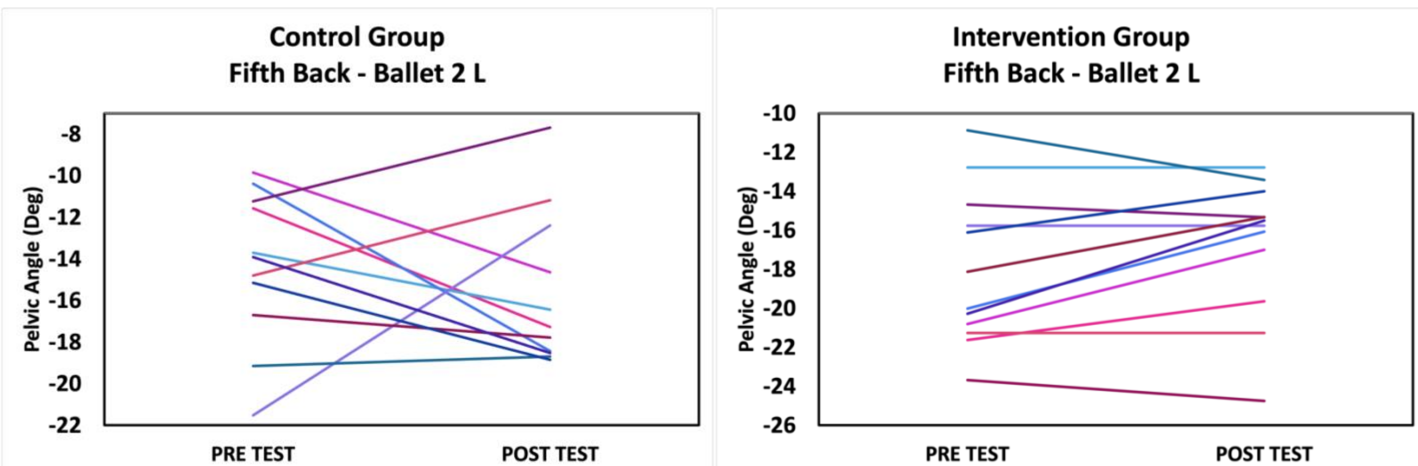

Figure 13: Comparison of Participants Ballet 2 L
Side by side comparison of individual participants sagittal pelvic alignment for pre-test and post-test on the right side. No trend is shown for the control group or intervention group for ballet 2 on the left side.

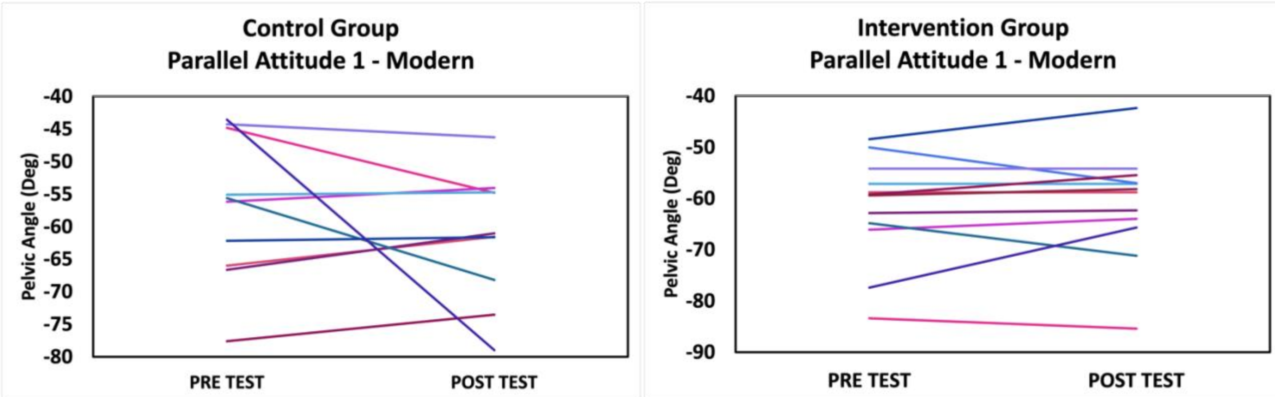

Figure 14: Comparison of Participants Modern
Side by side comparison of individual participants sagittal pelvic alignment for pre-test and post-test on the right side. No trend is shown for the control group or intervention group for modern.

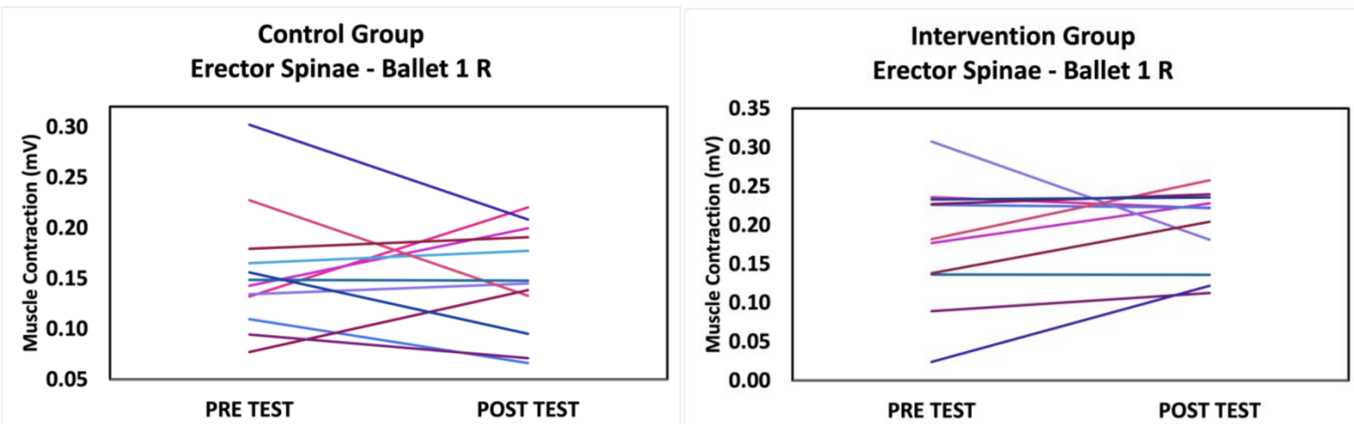

Figure 15: Comparison of Participants Erector Spinae Ballet 1 R
Side by side comparison of individual participants erector spinae muscle activation for pre-test and post-test on the right side. No trend is shown for the control group or intervention group for ballet 1.

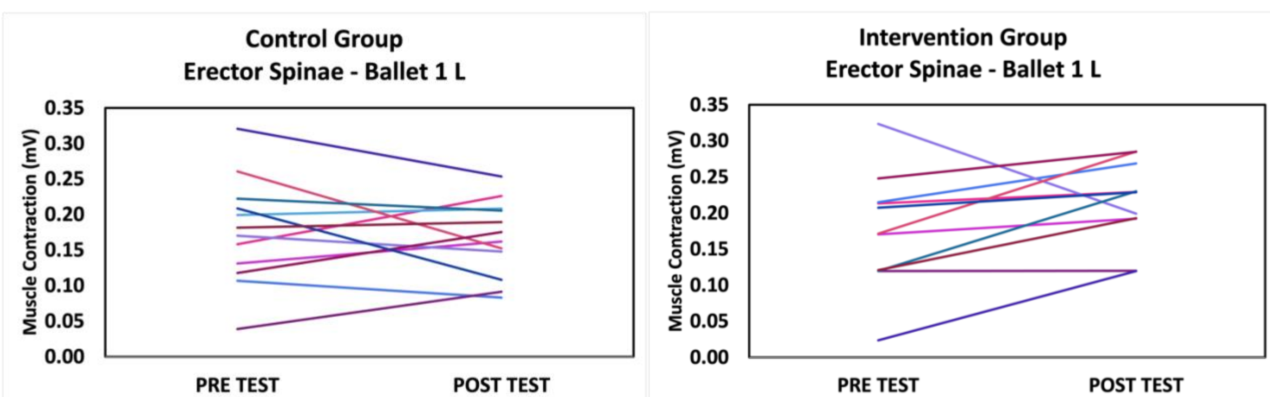

Figure 16: Comparison of Participants Erector Spinae Ballet 1 L
Side by side comparison of individual participants erector spinae muscle activation for pre-test and post-test on the left side. No trend is shown for the control group or intervention group for ballet 1.

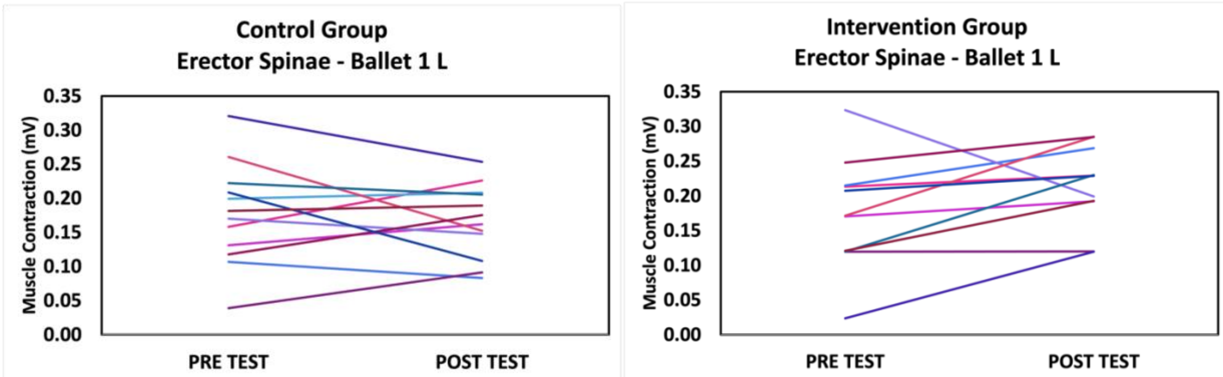

Figure 17: Comparison of Participants Rectus Femoris Ballet 1 R
Side by side comparison of individual participants rectus femoris muscle activation for pre-test and post-test on the left side. No trend is shown for the control group or intervention group for ballet 1.

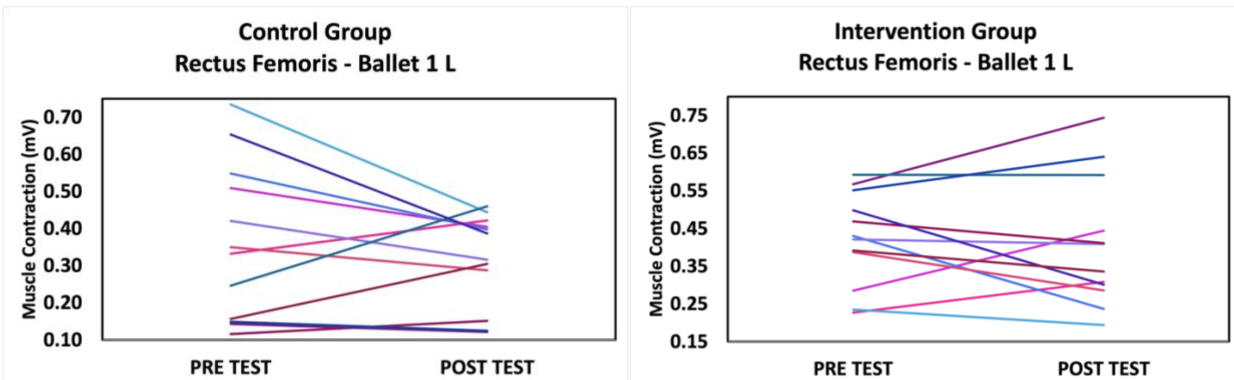

Figure 18: Comparison of Participants Rectus Femoris Ballet 1 L
Side by side comparison of individual participants rectus femoris muscle activation for pre-test and post-test on the left side. No trend is shown for the control group or intervention group for ballet 1.

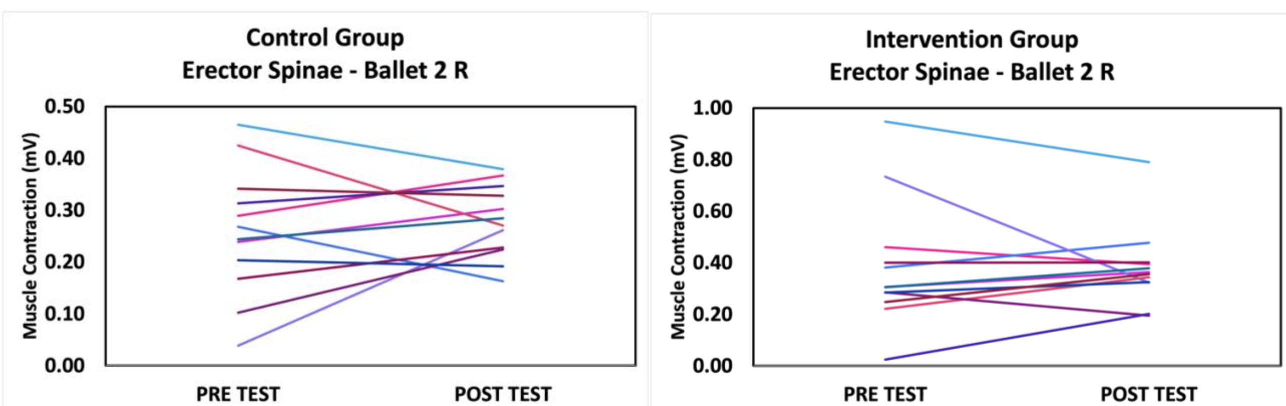

Figure 19: Comparison of Participants Erector Spinae Ballet 2 R
Side by side comparison of individual participants erector spinae muscle activation for pre-test and post-test on the right side. No trend is shown for the control group or intervention group for ballet 2.

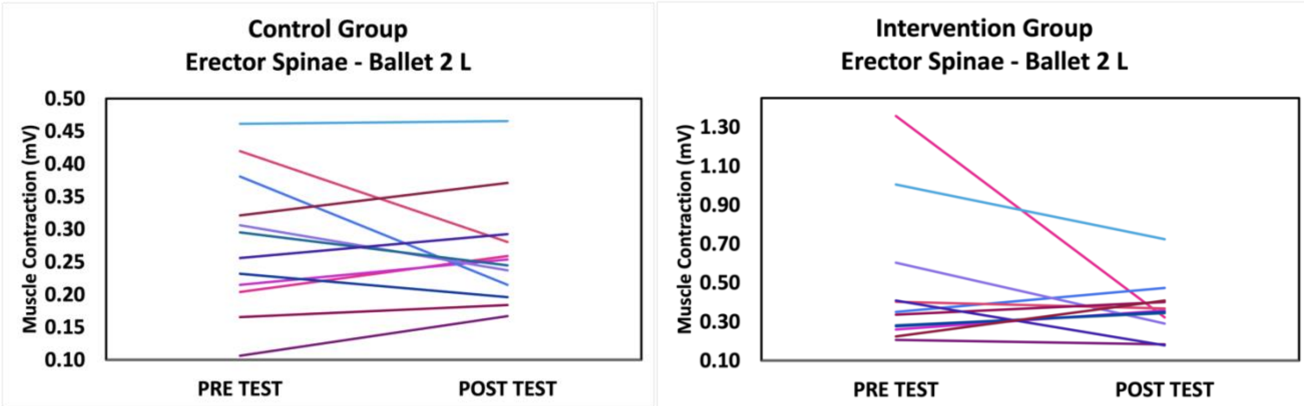

Figure 20: Comparison of Participants Erector Spinae Ballet 2 L
Side by side comparison of individual participants erector spinae muscle activation for pre-test and post-test on the left side. The intervention group decreased the average muscle activation in the erector spinae, while the control group stayed the same.

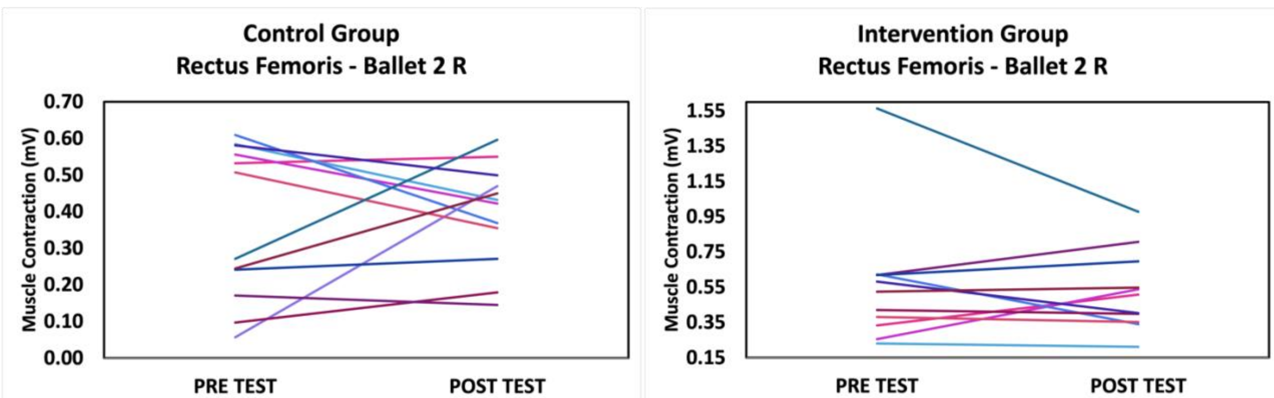

Figure 21: Comparison of Participants Rectus Femoris Ballet 2 R
Side by side comparison of individual participants rectus femoris muscle activation for pre-test and post-test on the right side. No trend is shown for the control group or intervention group for ballet 2.

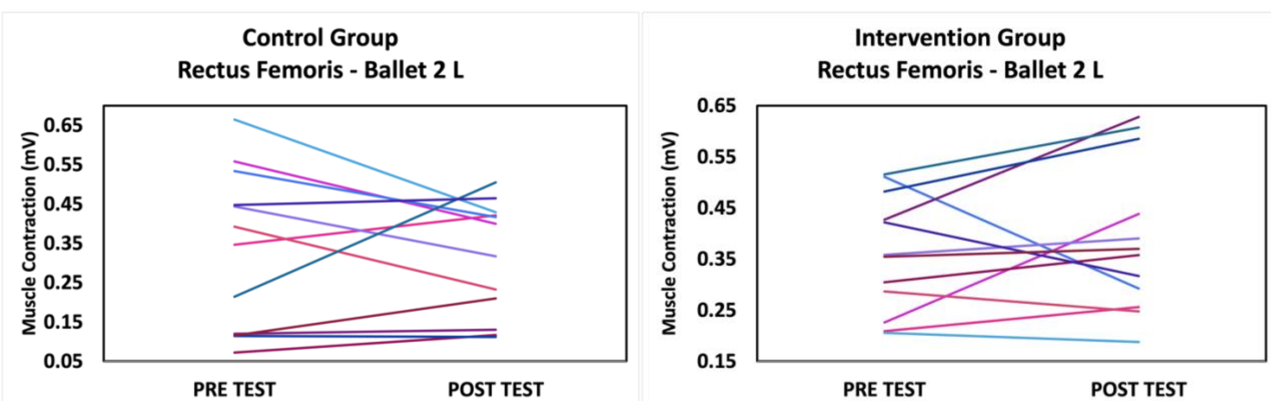

Figure 22: Comparison of Participants Rectus Femoris Ballet 2 L
Side by side comparison of individual participants rectus femoris muscle activation for pre-test and post-test on the left side. No trend is shown for the control group or intervention group for ballet 2.

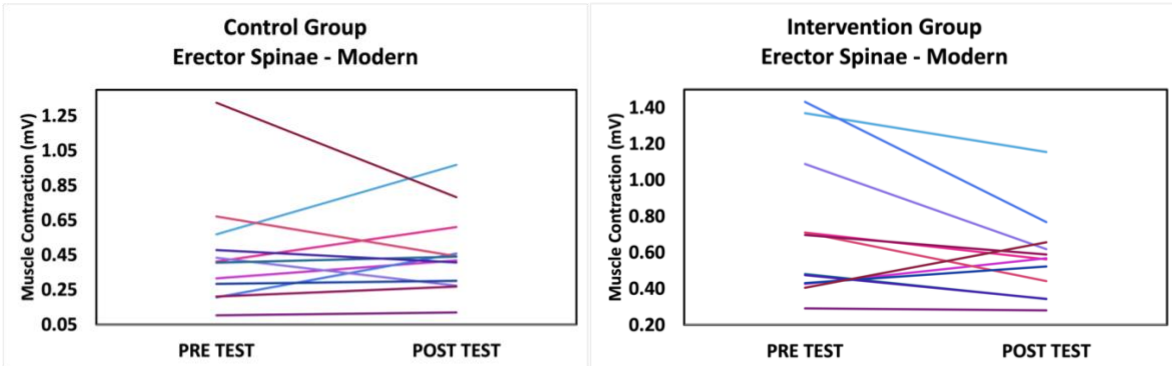

Figure 23: Comparison of Participants Erector Spinae Modern
Side by side comparison of individual participants erector spinae muscle activation for pre-test and post-test. No interaction was found

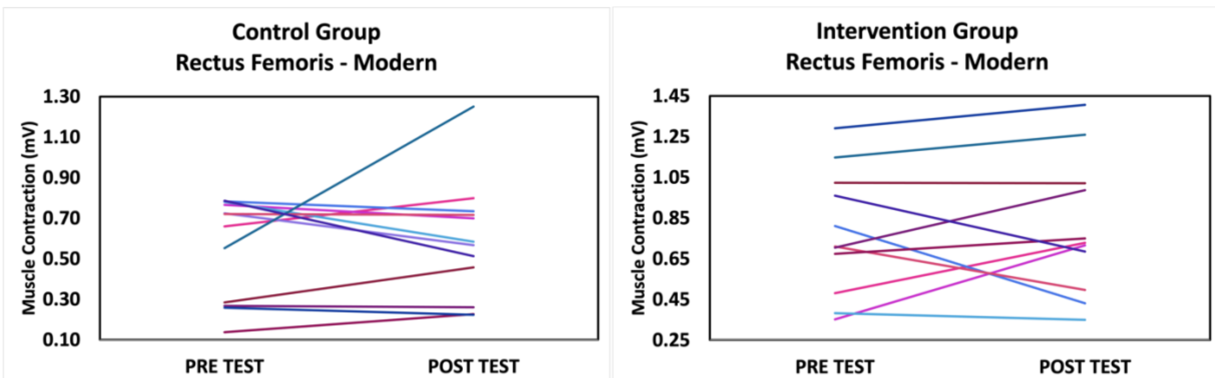

Figure 24: Comparison of Participants Rectus Femoris Modern
Side by side comparison of individual participants rectus femoris muscle activation for pre-test and post-test. No interaction was found.

Appendix F: Label List

RILIC – Right Iliac Crest
LILIC – Left Iliac Crest
RASIS – Right Anterior Superior Iliac Spine
LASIS – Left Anterior Superior Iliac Spine
RPSIS – Right Posterior Superior Iliac Spine
LPSIS – Left Posterior Superior Iliac Spine
RGRT – Right Greater Trochanter
LGRT – Left Greater Trochanter
RT1 – Right Thigh marker 1 (Top left marker)
RT2 – Right Thigh marker 2 (Top right marker)
RT3 – Right Thigh marker 3 (Bottom left marker)
RT4 – Right Thigh marker 4 (Bottom right marker)
LT1 – Left Thigh marker 1 (Top left marker)
LT2 – Left Thigh marker 2 (Top right marker)
LT3 – Left Thigh marker 3 (Bottom left marker)
LT4 – Left Thigh marker 4 (Bottom right marker)
RMK – Right Medial Knee
RLK – Right Lateral Knee
LMK – Left Medial Knee
LLK – Left Lateral Knee
RS1 – Right Shank marker 1 (Top left marker)
RS2 – Right Shank marker 2 (Top right marker)
RS3 – Right Shank marker 3 (Bottom left marker)
RS4 – Right Shank marker 4 (Bottom right marker)
LS1 – Left Shank marker 1 (Top left marker)
LS2 – Left Shank marker 2 (Top right marker)
LS3 – Left Shank marker 3 (Bottom left marker)
LS4 – Left Shank marker 4 (Bottom right marker)
RMM – Right Medial Malleolus
RLM – Right Lateral Malleolus
LMM – Left Medial Malleolus
LLM – Left Lateral Malleolus
RF1 – Right Foot Marker 1 (closest to RLM)
RF2 – Right Foot Marker 2 (directly below RF1)
RF3 – Right Foot Marker 3 (directly beside RF2)
R1 – Right Metatarsal 1
R5 – Right Metatarsal 5
LF1 – Left Foot Marker 1 (closest to LLM)
LF2 – Left Foot Marker 2 (directly below RF1)
LF3 – Left Foot Marker 3 (directly beside RF2)
L1 – Left Metatarsal 1
L5 – Left Metatarsal 5