5-2015

The Effects of Instruction on Landing Strategies in Female College-Aged Dancers and Non-Dancers: A Pilot Study

Brittany Keating
University of Nevada, Las Vegas

Jason Pyfer
University of Nevada, Las Vegas

Kimberly Vialpando
University of Nevada, Las Vegas

THE EFFECTS OF INSTRUCTION ON LANDING STRATEGIES IN FEMALE COLLEGE-AGED DANCERS AND NON-DANCERS: A PILOT STUDY

By

Brittany Keating
Jason Pyfer
Kimberly Vialpando

A doctoral project submitted in partial fulfillment of the requirements for the

Doctorate of Physical Therapy

Department of Physical Therapy
School of Allied Health Sciences
The Graduate College

University of Nevada, Las Vegas
May 2015

We recommend the doctoral project prepared under our supervision by

Brittany Keating, Jason Pyfer, and Kimberly Vialpando

entitled

The Effects of Instruction on Landing Strategies in Female College-Aged Dancers and Non-Dancers: A Pilot Study

is approved in partial fulfillment of the requirements for the degree of

Doctor of Physical Therapy
Department of Physical Therapy

Kai Yu Ho, Ph.D., Research Project Coordinator
Szu-Ping Lee, Ph.D., Research Project Advisor
Catherine Turner, D.P.T., Research Project Advisor
Merrill Landers, Ph.D., Chair, Department Chair Physical Therapy
Kathryn Hausbeck Korgan, Ph.D., Interim Dean of the Graduate College

May 2015

ABSTRACT

Background Female athletic participation has increased over the past decade and with it the prevalence of knee injuries. Current research demonstrates an increased risk of anterior cruciate ligament (ACL) injury for female athletes. However, a number of studies have pointed out that ballet and modern dancers exhibit a lower incidence of ACL injuries despite the fact that they perform jumping and landing frequently.

Objective The objective of this study was to examine how dance experience and instruction affect the lower extremity biomechanics during drop landings. Specifically, lower extremity joint alignment and muscle activation of gluteus maximus and gluteus medius were assessed.

Design Quasi-experimental, cross-sectional

Methods Thirteen active women, 5 dancers and 8 non-dancers, 18-22 years of age, were recruited to participate in this study. In the non-instructed (NI) condition, participants were shown a video demonstrating the drop landing movement in a leg turned out (externally rotated) position. The participants performed the drop landing based on their interpretation of the movement on the video. They were then shown the same video with additional verbal instructions (VI) on how to perform the landing, and asked to perform the same drop landing again. Surface electromyography (EMG) was used to measure muscle activation of the gluteus medius and gluteus maximus during the landings. Kinematics of the lower extremity joints during the deceleration phase of landing were acquired using a digital motion capture system. 2x2 repeated measures ANOVA's were used to assess the effect of dance experience (dancers and non-dancers) and verbal instruction (NI and VI) on lower extremity biomechanics and gluteal muscle activation.

Results The 2-way ANOVA revealed a significant group by condition interaction with right gluteus medius (p=0.003) and right glut maximus (p=0.009). Dancers showed a significant increase in gluteus medius ($p=0.02$) while non-dancers showed a significant decrease in gluteus medius ($p=0.04$) with verbal instruction. Both groups showed significant changes in knee valgus ($p<0.001$), hip abduction ($p=0.027$), and hip internal rotation ($p=0.031$) with verbal instruction. No significant differences were found when comparing those kinematic variables between groups.

Discussion and Conclusion Our results demonstrated that brief verbal instruction has an effect on landing kinematics in college aged women. For both dancer and non-dancers, decreased knee valgus, decreased hip internal rotation, and increased hip abduction were found after verbal instruction was given. In addition, dancers exhibited increased gluteal muscle activation with instruction whereas non-dancers showed a decrease in gluteal muscle activation with instruction. Our findings indicated that explicit movement instruction may result in diminished muscle activation in non-dancers. The heightened awareness of neuromuscular control from dance training may be related to the reduced knee injury risk.

ACKNOWLEDGEMENTS

We would like to thank the UNLV dance department for their help and cooperation with our subject recruitment. We would also like to thank Josh Bailey and the UNLV department of Kinesiology for allowing us to use the lab. Lastly we would like to thank the UNLV department of Physical Therapy faculty for their mentorship through this process. Specifically we would like to acknowledge Dr. Catherine Turner, Dr. Szu-Ping Lee, and Dr. Kai Yu Ho.

TABLE OF CONTENTS:

LIST OF TABLES:

LIST OF FIGURES:

INTRODUCTION

Female athletic participation has increased over the past decade and with it the prevalence of knee injuries.[1] The anterior cruciate ligament is the most commonly injured ligament in the knee.[2] Female athletes have a higher incidence of ACL injury than their male counterparts participating in the same sport.[3] Each year female athletes suffer ACL injuries at a 4 to 6 fold greater rate than their male counterparts.[1] The cost per ACL injury including surgery and rehabilitation is quite high per individual at 17,000 to 25,000 US dollars.[3] This translates into the cost of ACL injuries each year to 646 million US dollars. The time to return to sport can be a year or more.[4]

Non-contact ACL injuries account for 70% of overall ACL injuries.[5] The body of literature regarding risk factors associated with ACL injury is extensive. In female athletes joint laxity[6], genu recurvatum[7], ACL size[8], and the effects of estrogen[8] on ligament strength have been proposed as possible explanations for the increased risk of ACL injuries in women.[9] These are risk factors that are inherent in the physiology of an athlete and cannot be affected by injury prevention programs. One of the main factors believed to be involved in non-contact ACL injuries are frontal plane kinematics during limb loading (i.e. landing and cutting). It has been shown that increased hip adduction and internal rotation during limb loading can lead to increased knee valgus that stresses the ACL.[10,11] These frontal plane kinematics are something that may affected by improving hip muscle performance and can be a factor considered when developing an ACL injury prevention program.

Few studies have addressed the relatively uncommon occurrence of ACL injures in ballet and modern dancers. It has been estimated that ACL injuries in dancers occur with an incidence of 0.009 out of 1000 exposures.[12] In comparison, ACL injuries in female athletes have been reported to occur with an incidence of 0.31 per 1000 hours of soccer and 0.29 per 1000 hours of basketball exposure.[1, 13] In other words, the risk of dancers sustaining an ACL injury is 6 to 30 times smaller than athletes in other sports. Considering the amount of jumping and landing involved in dancing, it is puzzling that the risk of non-contact ACL injury can be so much lower. One potential explanation is the extensive training and practice that a dancer receives beginning at a young age. Female ballet dancers often begin training in dance around the age of 6 to 7 years.[14] This training focuses on balance, alignment, and neuromuscular control during landing.[12] They are also trained in a toe out or turnout position, which involves hip external rotation. The gluteus maximus is involved in hip abduction, extension, and external rotation and is the main muscle involved in hip external rotation, whereas the gluteus medius is involved in abduction and stabilization of the hip.[15] As such, the extensive training may afford the dancers movement and muscle activation patterns that reduce the risk for ACL injury. Furthermore, verbal instruction and feedback is an integral part of dance training. It has been proposed that simple verbal instruction can improve knee biomechanics when landing.[16]

The overall purpose of the study was to examine how dance experience and instruction affect the lower extremity biomechanics during drop landings. Specifically, lower extremity joint alignment and muscle activation of gluteus maximus and gluteus medius were assessed. We hypothesized that dancers would exhibit 1) increased gluteus maximus and gluteus medius activation, and 2) smaller knee valgus angle, hip adduction angle, and hip internal rotation angle. Additionally, we hypothesized that verbal instruction will increase gluteal muscle activation and promote a more neutral lower extremity landing pattern.

METHODS

Settings and Participants

Five female dancers and eight female non-dancers participated. Dancers were recruited as a sample of convenience from the University of Nevada Las Vegas (UNLV) Dance Department and the non-dancers were recruited from the UNLV student body. Participants were female, between the ages of 18 and 22 with no previous knee injuries. Dancers must have studied dance for a minimum of 7 years and to be receiving dance training at least 12 hours a week at the time of study.[17,18,19] Non-dancers must be physically active (i.e. exercise 2-3 times per week for 30 minutes at a time) and have had no formal dance training for the last ten years. Inclusion to the study was determined with the use of a written survey. Participants were excluded if they did not meet these requirements.

Instrumentation

Hip muscle strength was measured using a handheld MicroFET 2© dynamometer. Hip range of motion was measured using a goniometer. Gluteus maximus and gluteus medius activation were assessed using a wireless surface electromyography (EMG) system (Delsys Inc., Natick, MA) with a sampling rate of 2000 Hz. Lower extremity 3D kinematic data was assessed using a Vicon© digital motion capturing system with a sampling rate of 200 Hz.

Procedures

Prior to data collection an informed consent form, as approved by the UNLV institutional review board, was signed and collected from each participant. The participants were asked to complete a survey to collect their demographic information (Table 1) as well as physical activity level. Activity level was measured by asking participants if they participated in exercise, what type of exercise and how often per week they performed this exercise.

Hip external rotation (turn out) range of motion was measured in each participant. They were asked to lie in supine and turn their feet out as far as they could. The goniometer was placed with the fulcrum at the calcaneus. The stationary arm was placed perpendicular to the floor and the moving arm was along the second metatarsal (Fig 1).[20]

Preparation of Muscle Activation Assessment

Electromyographic sensors were placed on the muscle belly of the right and left gluteus maximus and gluteus medius. Skin was prepped using alcohol pads to clean the surface area. Once skin was dry, self-adhesive surface electrodes were firmly attached to the skin surface. For gluteus maximus, participants were placed in a prone position, then surface electrodes were placed lateral to the sacrum and placed on the predominant part of the muscle belly along the direction of the muscle fibers. The participant's knee was bent to 90 degrees and then asked to contract the hip extensor muscle as to lift their thigh off the table directly up towards the ceiling. The participant repeated this motion a few times to get the best signal quality and the surface electrode was secured to the muscle. For gluteus medius, participants were placed in sidelying with knees extended. The greater trochanter was palpated and then surface electrodes were placed superior-posteriorly to the greater trochanter on the predominant part of the muscle belly, along the direction of the muscle fibers. The participant was then asked to contract the hip abductor muscles as to lift their leg up toward the ceiling in the sidelying position, while keeping the knee straight. The participant repeated this motion a few times to get the best signal reading and the surface electrode was adjusted as needed before being secured.

Electrodes were further secured with elastic film tape to decrease excess motion and improve surface contact of the electrode during activity. Once all 4 electrodes were secured, maximal voluntary isometric contraction (MVIC) testing was performed for hip abduction, hip external rotation and hip extension bilaterally. Abduction and external rotation MVIC assessments (Fig 2 and 3) were set up as described by Leetun, et al. with the exception that a strap was placed over both lower extremities when performing external rotation in order to secure the strap properly and prevent excess motion.[21] Hip extension (Fig 4) was set up as described by Stearns, et al.[22] Participants performed 3 trials, holding the isometric maximal contraction for 5 seconds each time. The hand held dynamometer was zeroed out after each trial.

Reflective markers were placed on the participant using the Vicon Plug-in Gait full-body marker set. A static calibration trial that acquires the body geometry was collected and then participants were asked to complete a five-minute warm up on an elliptical machine at a self-selected pace. Testing of the 2 conditions then began.

Biomechanical Evaluation of Drop Landing

Participants completed the drop landings from a 30.5 cm box [14, 23, 24] It should be noted that all participants performed the test conditions with bare feet.[10,18,25] Participants were expected to complete 2 test conditions: No instruction (NI) and verbal instruction (VI). In NI, they were shown a video demonstrating a drop landing into maximal external rotation (turn out).[25] Participants were not given any verbal instruction at this time prior to performing the landings. They were allowed to practice each landing 3 times before performing 3 captured landing trials.[23] After completing the NI landings, in condition VI, participants watched the same video but now had a specific set of verbal instructions on how to perform the drop landing into maximal external rotation. The instructions focused on the position of the body segments (i.e. trunk, hips, knees, and toes) during landing. Complete instruction can be found in table 2. The participants were given time to practice the jumps and were given feedback on their movement during the practice landings. When they felt ready they performed 3 captured landing trials.

Data Analysis

Data from the right leg was processed and analyzed in our analysis. Collected EMG signals were bandpass filtered (35-500Hz, 4th order Butterworth filter), then full-wave rectified. The marker data were low-pass filtered with a cutoff frequency of 12 Hz. The joint kinematics were computed from the filtered data using a software package (Visual 3D, C-motion Inc., Rockville, MD). Muscle activation and joint kinematic variables were extracted from the deceleration phase of the drop landing trials. The deceleration phase was defined as from the point of initial contact to when the knee flexion angle was greatest during a landing. Muscle activations of the gluteus medius and maximus muscles during this period were time-averaged and normalized as a percentage to the maximal muscular contraction levels obtained during the MVIC trials. Lower extremity joint kinematic variables were analyzed; specifically peak hip flexion, adduction, abduction, internal and external rotation. Peak knee flexion and valgus angles were also investigated.

Statistical Analysis

Demographic information of the participants was compared using an independent t-test, specifically comparing age, height, weight, BMI, hip muscle MVIC and hip ER.

A 2x2 repeated measures analyses of variance on SPSS version 22 (IBM Corp. Armonk, NY) was utilized to investigate the effects of instruction (NI vs.VI) and group (dancers vs. non-dancers) on the lower extremity biomechanics and activation levels of the hip muscles. When a significant interaction was found, post-hoc pair-wise comparisons with Bonferroni corrections were performed. A significance level was set at $p \leq 0.05$.

RESULTS

Independent t-tests revealed no significant differences in age, height, weight, BMI, hip muscle MVIC, or hip ER between dancers and non-dancers (Table1).

The 2 way ANOVA revealed no significant differences in any of the variables when comparing between groups. Verbal instruction had a significant effect on knee valgus (7.73±3.3 vs. 10.42±2.5 , $p<0.01$), hip abduction (18.17±5.1 vs. 20.77±5.1, $p=0.03$), and hip internal rotation (14.75±8.2 vs. 11.02±8.9, $p=0.03$). With instruction each group was able to improve landing mechanics.

The 2-way ANOVA revealed a significant group by condition interaction with right gluteus medius ($p=0.009$) and right gluteus maximus ($p=0.003$) activation (Figure 5,6). post-hoc

Post-hoc pair-wise comparisons with Bonferroni corrections showed that with instruction, dancers had a significant increase in gluteus medius activation (0.188±0.076 vs. 0.276±0.126; p=0.02) and marginally significant increase in gluteus maximus activation (0.336±0.157 vs. 0.437±0.126; p=0.06) (Figure 7,8). Non-dancers were found to have a significant decrease in gluteus medius activation (0.441±0.246 vs. 0.366±0.207; p=0.041) and a trend of reduction in gluteus maximus activation (0.374±0.185 vs. 0.298±0.138; p=0.08) after receiving instruction (Figure 7,8).

DISCUSSION

Our primary findings showed that both groups demonstrated significantly decreased knee valgus angle and hip internal rotation, as well as increased hip abduction angle in the VI condition. Our results also demonstrated that dancers and non-dancers reacted differently when given instruction. Non-dancers' gluteal activation decreased with instruction, while dancer's gluteal activation increased.

With these findings, it is important for us to investigate potential mechanisms for these results. Preventing ACL injuries is a top priority among many in the athletic field. Research has been done on the importance of using a training program as a means of injury prevention. Frequently, these studies focus on neuromuscular and proprioceptive training, for example, the PEP program. The PEP program involved high school female soccer players, ages 14-18, and the use of the Prevent Injury and Enhance Performance (PEP) program.[27, 28] The PEP program consisted of stretching, strengthening, and plyometric activities and included a set of verbal instructions, as well as an instructional video that the coaches showed their players and used throughout the season. The instructional video emphasized proper landing techniques.[27] Overall researchers found a 74% - 88% decrease in non-contact ACL injuries over the course of 2 years.[27] These findings, as well as our results, indicate that a training program that provides education and demonstration of proper biomechanical landing techniques, can aide in ACL injury prevention.

It can be suggested that the use of a training program allows for the development of neuromuscular control. Dancers have demonstrated a lower incidence of ACL injury compared to other athletes. As dancers, and other athletes, learn from techniques they also develop an ability to promote feed-forward mechanisms. Feedback mechanisms are techniques used to react to a situation, whereas feed-forward allows the body to anticipate what is about to happen and prepare the body, whether it be through biomechanics or muscular activity. Giving instruction and setting up a training program helps to educate the dancer on proper form, as well as enhance their ability to prepare using feed-forward mechanisms.

Other research has shown that in general, giving instruction is better than not giving instruction to complete a task properly. Milner et al found that giving three simple additional verbal cues to their participants improved knee biomechanics compared to the control jump, which did not provide any specific verbal cueing regarding jump mechanics.[16] It is also important to consider the type of instruction that is given. Other studies have looked extensively at the effects of the type of instruction given, such as instruction with an internal or external focus.[29, 30] Theverbal instructions used in this study may have negatively influenced the neuromuscular activation of non-dancers as the cues were focused on the body segments. Dancers on the other hand, are used to receiving a combination of internally and externally focused instruction. The long-term dance training perhaps reinforced the association between body segment movements and muscle activation. For example, dancers may associate the "turn out" position with activation of hip external rotators. Further research could be done to look at the effects of internally versus externally focused instruction on neuromuscular activation, as well as the biomechanics of landing.

With the instructions focused on the body segments and not activating gluteal muscles, we hypothesize that non-dancers may have been overwhelmed by the amount of instruction and feedback given[31], therefore they attempted to focus more on the verbal cues to maintain the correct position. As a novice, non-dancers may be in the cognitive stage of motor learning and are unable to process too much instruction. While participants were shown the video with instruction, it was observed that non-dancers were more attentive to the video and asked more questions about mechanics than dancers.

Dancers, on the other hand, are used to receiving instruction and feedback on their form. When a young dancer initially learns a new task, the preferred form of instruction is a demonstration of the activity. This is considered a "watching and doing" learning strategy. Early dance training also involves multiple repetitions of a task with constant feedback regarding form which contributes to neuromuscular control. Verbal feedback is a secondary teaching strategy at this stage of learning. As the dancer progress from recreational dance to professional dance, less internal and external feedback is given and dancers are encouraged to begin to "self-instruct".[33] Dancers in our study had to have at least 7 years of dance training. They are therefore in the late stages of motor learning so they did not need to focus solely on the mechanics like non-dancers. Dancers were observed to be less attentive with the VI video, which we attribute to their years of dance training.

Dance training may provide neuromuscular and proprioceptive control of the muscle groups responsible for maintaining abduction and external rotation of the hip during landing. Non-dancers showed a decrease in muscle activation when given instruction. At the same time dancers showed an increase in muscle activation when given instruction. We hypothesize that dancers have increased neuromuscular control and are able to translate verbal cues to activate the gluteal muscles and improve biomechanical results due to their focus on jump training during their developmental years.[12, 32] When given instruction, instead of focusing on the mechanics like the non-dancers did, dancers were able to take the instruction and increase activation of the gluteal muscles to help maintain the proper mechanics, acting as a preventative measure. This indicates that dancers benefit from jump training and their ability to utilize their muscles in a way that demonstrates biomechanical protection and reduce risk of ACL injury.

Limitations

The purpose of this study was to determine if there were any differences between dancers and non-dancers in muscle activation and landing kinematics due to instruction. We were interested in a comparison of college-aged dancers who receive extensive jump training and athletic individuals with little to no jump training. One large limitation in this study was the small number of participants that were dancers. Initially we were hoping to recruit ballet dancers specifically who train in hip external rotation or “turn out”. We chose to use a pool of dancers from the University of Nevada Las Vegas’ dance program as a sample of convenience and most of them had mixed training experience in both modern and ballet dance. Our overall sample size was also quite small. This was a pilot study and further research needs to be conducted in order to verify our initial findings. Specifically, it would be interesting to look into the effects of internally versus externally focused instruction to see if it would make a greater difference in the mechanics, as well as neuromuscular activation of the gluteal muscles. It would also be interesting to compare female dancers with other female athletes who participate in sports such as soccer, volleyball and basketball to further look at the differences between these groups in an attempt to improve on a future training program that can help to increase injury prevention.

CONCLUSION

This pilot study demonstrates that brief instruction has an effect on landing kinematics in college-aged women. For both dancers and non-dancers, decreased knee valgus, decreased hip internal rotation and increased hip abduction were found after verbal instruction was given. Participants were able to demonstrate landing mechanics that placed them at a decreased risk for ACL injuries.

In addition, dancers exhibited increased gluteal muscle activation with instruction, whereas non-dancers showed a decrease in gluteal muscle activation with instruction. Based on these findings it can be assumed that dancers have undergone training that has increased their neuromuscular control and are able to activate their gluteal muscles as a preventative measure, as well as to aid in proper mechanics. This may provide some insight into the decreased frequency of ACL injuries reported to date in the research within this population. In the physical therapy profession, helping patients not only rehabilitate, but prevent injury from occurring, stands as a major goal. Our initial findings do indicate components of dance training including development of neuromuscular control and activation, perhaps through repetitive jump training, may indeed provide a protective effect in preventing ACL injury. Further research needs to investigate if specific elements of dance training might be beneficial to incorporate into injury prevention training programs, particularly for sports commonly associated with increased risk of ACL injury.

APPENDIX A

Table 1: Demographic and Anthropometric Information of the Participants

	Mean		P-value
	Dancer N=(5)	Non-Dancer N=(8)	
Age (yrs)	19.8±1.1	21±1.1	**0.077**
Height (m)	1.69±0.1	1.63±0.1	**0.22**
Weight (kg)	62.44±7.1	58.43±7.9	**0.375**
BMI (kg/m^2)	21.9±3.1	21.87±2.1	**0.987**
MVIC Right ABD (N)	57.08±8.7	55.31±14.3	**0.809**
MVIC Right Ext (N)	91.44±9.4	95.73±22.1	**0.693**
MVIC Right ER (N)	26.98±2.4	23.34±3.2	**0.053**
Right Hip ROM ER (degrees)	52.2±5.8	62±12.7	**0.136**

Table 2: Instructions Given to Each Participant for Condition VI

Drop landing in max external rotation	Place your feet hip width apart and toes pointing forward, Be sure to place the balls of your feet at the front edge of the box so your toes are just hanging off. Stand with trunk erect. When you are ready, please jump off the box and land on the ground in a maximum turned out position. This is the same landing position as performed in test condition 3. Make sure to only turn out your feet to the maximum position that is still comfortable to maintain throughout the landing. Focus on having your toes touch down first, and then your heels. Remember to maintain an upright trunk and do not let your knees fall in towards each other when landing.
Participants were instructed to keep their hands on their hips at all times and to keep their eyes looking forward ** **When positioning themselves into external rotation, if any "screwing in" or "compensated turnout" was noticed by the researcher, participants were verbally corrected by researcher in order to ensure safety[26] **Compensations that were looked for include anterior pelvic tilt, pronation of the feet or "screwing in."[26] "Screwing in" occurs when a dancer attempts to reach a position of further turnout that goes beyond their natural limit, which they do by compensating other body mechanics. All of these compensations help to increase external rotation at the hips and were corrected if seen by the researcher**	

Figure 1. Measurement Procedure for Turnout

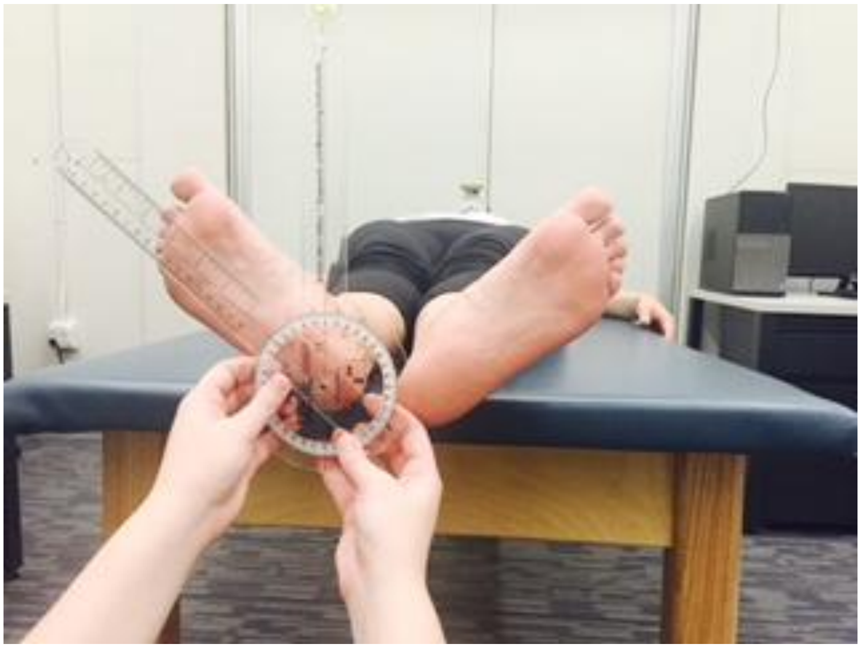


Figure 2. Hip Abduction MVIC

Figure 3. Hip External Rotation MVIC

Figure 4. Hip Extension MVIC

Figure 5. NI vs VI Gluteus Maximus EMG Group by Condition Interaction

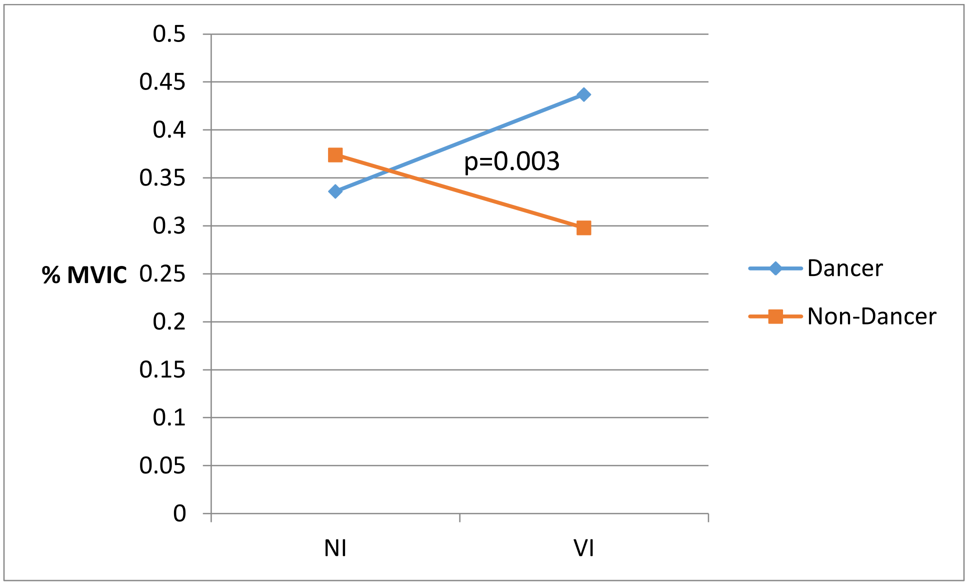


Figure 6. NI vs VI Gluteus Medius EMG Group by Condition Interaction

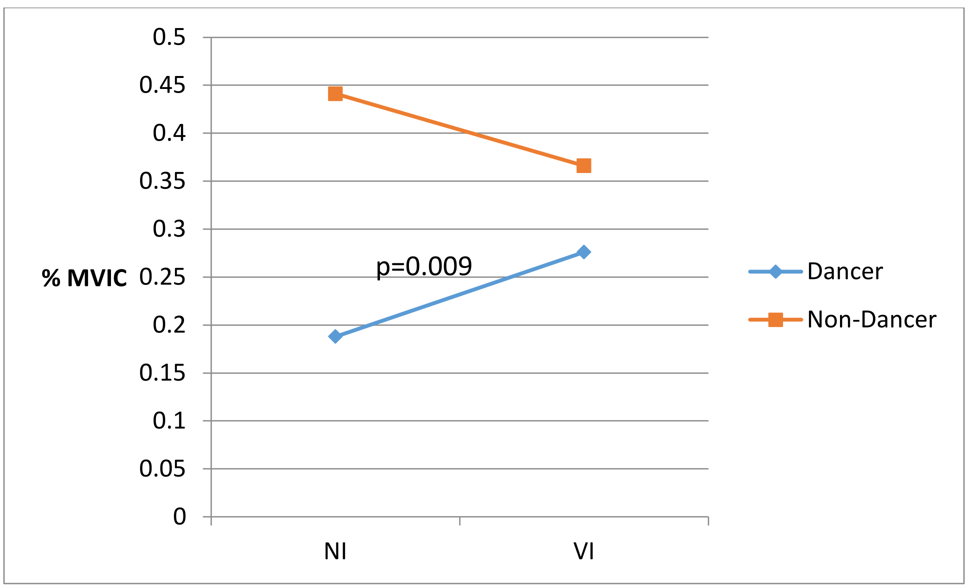


Figure 7. Post Hoc Comparison Gluteus Medius

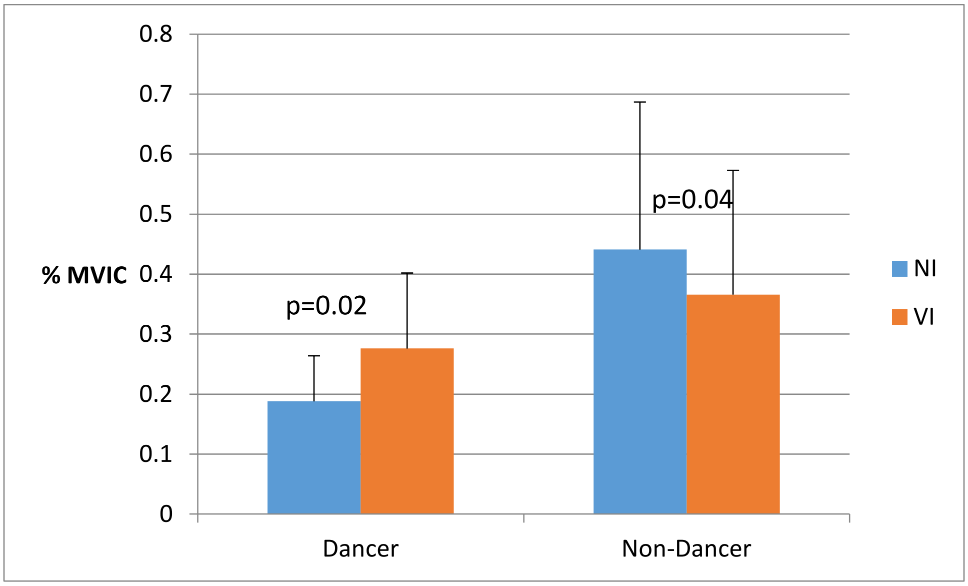
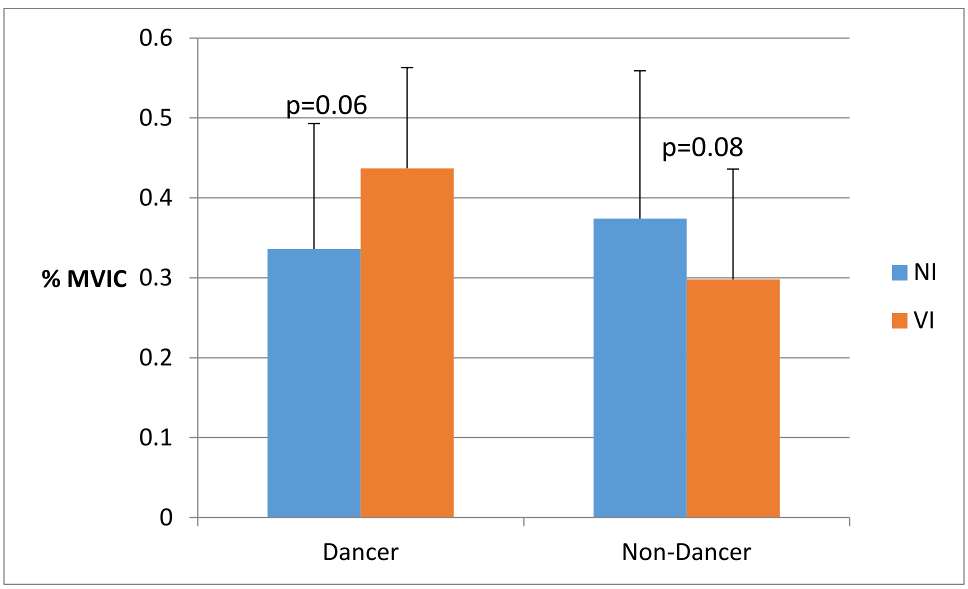


Figure 8. Post Hoc Comparison Gluteus Maximus



References:

1. Arendt EA, Agel J, Dick R. Anterior cruciate ligament injury patterns among collegiate men and women. *J Athl Train.* 1999;34:86-92.
2. Majewski M, Habelt S, Steinbruck K. Epidemiology of athletic knee injuries: A 10 year study. *The Knee.* 2006;13:184-188.
3. Hewett TE, Myer GD, Ford KR. Anterior cruciate ligament injuries in female athletes: part 1, mechanisms and risk factors. *Am J Sports Med.* 2006;34:299-311.
4. Quatman CE, Quatman-Yates CC, Hewett TE. A 'plane' explanation of anterior cruciate ligament injury mechanisms. *Sports Med.* 2010;40:729-746.
5. Bates NA, Ford KR, Myer GD, et al. Kinetic and kinematic differences between first and second landings of a drop vertical jump task: Implications for injury risk assessment. *Clin Biomech.* 2013;4:459-466
6. Uhorchak JM, Scoville CR, Williams GN, et al. Risk factors associated with noncontact injury of the anterior cruciate ligament: A prospective four-year evaluation of 859 west point cadets. *Am J Sports Med.* 2003: 31: 831-842.
7. Kawahara K, Sekimoto T, Watanabe S, et al. Effect of genu recurvatum on the anerior cruciate ligament-deficient knee during gait. *Knee Surg Sports Traumatol Arthrosc.* 2012: 20: 1479-1487.
8. Chapell JD, Creighton RA, Guiliani C, et al. Kinematics and electromyography of landing preparation in vertical stop-jump: Risks for noncontact anterior cruciate ligament injury. *Am J Sports Med.* 2007: 35: 235-241.
9. Boden BP, Sheehan FT, Torg JS, Hewett TE. Noncontact anterior cruciate ligament injuries: mechanisms and risk factors. *J Am AcadOrthop Surg.* 2010;18:520-527.
10. Shultz SJ, Schmitz RJ. Effects of transverse and frontal plane knee laxity on hip and knee neuromechanics during drop landings. *Am J Sports Med.* 2009;37:1821.
11. Blackburn JT, Padua DA. Influence of trunk flexion on hip and knee joint kinematics during a controlled drop landing. *Clin Biomech. 2008: 23;313-319*
12. Liederbach M, Dilgen FE, Rose DJ. Incidence of anterior cruciate ligament injuries among elite ballet and modern dancers: a 5 year prospective study. *Am J Sports Med.* 2008;36:1779-1788.
13. Alentorn-Geli D, et al. Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. *Knee Surg Sports Traumatol Arthrosc.* 2009;17:705–729.
14. Orishimo KF, Kremenic IJ, Pappas E, Hagins M, Liederbach M. Comparison of landing biomechanics between male and female professional dancers. *Am J Sports Med.* 2009;37:2187-2194.
15. Jacobs CA, Uhl TL, Mattacola CG, Shapiro R, Rayens WS. Hip abductor function and lower extremity landing kinematics: sex differences. *J Athl Train.* 2007;42:76-83.
16. Milner CE, Fairbrother JT, Srivatsan A, Zhang S. Simple Verbal Instruction improves knee biomechanics during landing in female athletes. *Knee*. 2012; 19: 399-403.
17. Pozo-Municio C. Genitourinary conditions in young dancers: relationship between urinary incontinences and foot flexibility. *J Dance Med Sci*. 2007;11:49-59.
18. Simmons RW. Neuromuscular responses of trained ballet dancers to postural perturbations. *Intern. J. Neuroscience*. 2005;115:1193-1203.
19. Jola C, Davis A, Haggard P. Proprioceptive integration and body representation: insights into dancers' expertise. *Exp Brain Res.* 2011;213:257-265.
20. Grossman G, Waninger KN, Voloshin A, Reinus WR, Ross R, Stoltzfus J, Bibalo K. Reliability and Validity of Goniometric Turnout Measurements Compared with MRI and Retro-Reflective Markers. *J Dance Med Sci.*2008: 12: 142-152

21. Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. *Med Sci Sports Exerc.* 2004;36:926-934.
22. Stearns KM, Keim RG, Powers CM. Influence of relative hip and knee extensor muscle strength on landing biomechanics. *Med Sci Sports Exerc.* 2013;45:935-941.
23. Walsh MS, Waters J, Kersting UG. Gender bias on the effects of instruction on kinematic and kinetic jump parameters of high-level athletes. *Research in Sports Medicine.* 2007;15:283-295.
24. Carcia C, Eggen J, Shultz S. Hip-abductor fatigue, frontal-plane landing angle, and excursion during a drop jump. *J Sports Rehabil.* 2005;14:321-331.
25. Ambegaonkar JP, Shultz SJ, Perrin DH, et al. Lower body stiffness and muscle activity differences between female dancers and basketball players during drop jumps. *Sports Health.* 2011;2:89-96.
26. Coplan JA. Ballet dancer's turnout and its relationship to self-reported injury. *J Ortho Sports Phys Ther.* 2002: 32: 579-584.
27. Mandelbaum BR, Silvers HJ, Watanabe DS, et al. Effectiveness of a neuromuscular and proprioceptive training program in preventing the incidence of anterior cruciate ligament injuries in female athletes: 2-year follow up. *Am J Sports Med.* 2005: 33: 1003-1009.
28. Pollard CD, Sigward SM, Ota S, et al. The influence of in-season injury prevention training on lower extremity kinematics during landing in female soccor players. *Clin J Sport Med.* 2006: 16: 233-227.
29. Zachry T, Wulf G, Mercer J, Bezodis N. Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. *Brain Res Bull*. 2005; 67(4): 304-309.
30. Gokeler A, Benjaminse A, Welling W, Alferink M, Eppinga P, Otten B. The effects of attentional focus on jump performance and knee joint kinematics in patients after ACL reconstruction. *Phys Ther Sport.* 2014: 1-7.
31. Hodges NJ, Franks IM. Modelling coaching practice: the role of instruction and demonstration. *J Sports Sci.* 2010; 20: 793-811.
32. Nyland J, Burden R, Krupp R, Caborn DN. Whole body, long-axis rotational training improves lower extremity neuromuscular control during single leg lateral drop landing and stabilization. *Clin Biomech (Bristol, Avon)*. 2011; 26: 363-370.
33. Wilmerding V, Krasnow D. Motor learning and teaching dance. *J Dance Med Sci.* 2009: 1-6.

Curriculum Vitae

Brittany Keating

Education:

Graduate: University of Nevada Las Vegas 2012-2015
	Doctorate of Physical Therapy, expected graduation May 2015
Undergraduate: University of Nevada Las Vegas 2008 -2012
	Bachelor of Science in Kinesiology

Significant Coursework:

Anatomy and Physiology
Exercise Physiology
Neuroanatomy, Physiology and Rehabilitation
Orthopedic Principles, Assessment and Rehabilitation
Pediatrics
Geriatrics
Cardiopulmonary Rehabilitation
Research Methods and Statistics

Doctoral Dissertation:

Keating, Brittany, Pyfer, Jason, Vialpando, Kimberly. *The effects of instruction on landing strategies in female college-aged dancers: a pilot study.* 2013-2015.

Clinical Experience:

Sunrise Children's Hospital, Las Vegas, NV January 2015 – April 2015
	Examined and treated patients ranging in age from 1 month to 16 years old in the PICU and pediatric floor of the hospital, as well as in the outpatient setting
HealthSouth Henderson Rehab Hospital, Henderson, NV October 2014 – December 2015
	Examined and executed appropriate treatment plans for patients with diagnoses such as: CVA, MS, Parkinson's disease, total joint replacements and general debility
Mountain View Hospital, Las Vegas, NV July 2014 – September 2014
	Examined and treated patients in the acute care setting ranging from musculoskeletal to neurologic pathologies. Also assisted with wound care treatments including sharps debridement, dressing changes and wound vac placement
Tim Soder Physical Therapy, Henderson, NV July 2013 – August 2013
	Examined and treated patients with musculoskeletal pathologies, and assisted in developing appropriate physical therapy diagnoses and treatment plans

Professional Development:

APTA member 2012 – present
	Acute, pediatric and orthopedic sections
APTA Combined Sections Meeting Attendee 2013-2014
UNLV PT Distinguished Lecture Series 2012-2014

Curriculum Vitae

Jason Pyfer

Education:

Graduate: University of Nevada Las Vegas 2012-2015
-Doctorate of Physical Therapy, expected graduation May 2015
Undergraduate: Boise State University 2010 -2011
-Bachelor of Science in Kinesiology
Brigham Young University-Idaho 2005-2010

Significant Coursework:

Anatomy and Physiology
Exercise Physiology
Neuroanatomy, Physiology and Rehabilitation
Vestibular Rehabilitation
Orthopedic Principles, Assessment and Rehabilitation
Prosthetics and Orthotics
Pediatrics
Geriatrics
Cardiopulmonary Rehabilitation
Research Methods and Statistics

Doctoral Dissertation:

Keating, Brittany, Pyfer, Jason, Vialpando, Kimberly. *The effects of instruction on landing strategies in female college-aged dancers: a pilot study*. 2013-2015.

Clinical Experience:

Comprehensive Therapy Centers, Las Vegas, NV January 2015 – April 2015
Examined, evaluated and developed treatment plans for patients with musculoskeletal and vestibular pathologies in an outpatient orthopedic setting.
Kingman Regional Medical Center, Kingman, AZ October 2014 – December 2015
Examined and treated patients in the acute care setting ranging from musculoskeletal to neurologic pathologies. Shadowed orthopedic surgeries, wound care, and vestibular therapy.
HealthSouth Henderson Rehab Hospital, Henderson, NV July 2014 – September 2014
Examined and executed appropriate treatment plans for patients with diagnoses such as: CVA, MS, SCI, Parkinson's disease, total joint replacements and general debility
Kelly Hawkins Physical Therapy, Pahrump, NV July 2013 – August 2013
Examined and treated patients with musculoskeletal pathologies, and assisted in developing appropriate physical therapy diagnoses and treatment plans

Professional Development:

APTA member 2012 – present
Neurology, sports and orthopedic sections
APTA Combined Sections Meeting Attendee 2013-2014
UNLV PT Distinguished Lecture Series 2012-2014

KIMBERLY VIALPANDO

EDUCATION

University of Nevada, Las Vegas
Doctorate of Physical Therapy, expected May 2015

University of Nevada, Las Vegas
Bachelor of Science, Sports Injury Management, Dec 2015

RESEARCH

Doctoral Dissertation 2013-2015
Keating B, Pyfer J, Vialpando K. *The effects of instruction on landing strategies in female college-aged dancers: A pilot study.*

Research Assistant, Emergency Medicine Research Department, UMC:
"What is the utility of Vibration Response Imaging (VRI) in the emergency department setting?"
"Save a Life" Study
"Non-Invasive Hemoglobin Monitoring in Acute Trauma Care"
"EMS Tracking of Narcotic Prescriptions"

CLINICAL EXPERIENCE

VA Southern Nevada Healthcare System, North Las Vegas, NV, Jan-April 2015
Evaluation and treatment for the outpatient veteran population including adult and geriatric population. Patients had a diverse set of diagnosis including chronic orthopedic impairments, post-surgical, arthroplasty, amputees, spinal cord injury, stroke, TBI, balance impairments, and deconditioning.

Sunrise Hospital, Las Vegas NV, Oct-Dec 2014
Evaluation and treatment of various populations at a level II trauma hospital. Responsible for evaluating physical therapy needs for adult patients mainly on the med/surg unit and trauma/ICU however also able to work in orthopedic unit, oncology unit, psychiatric unit (L2K), and neuro ICU.

Advanced Healthcare, Las Vegas, NV, July-Sep 2014
Evaluation, treatment, and discharge planning for an adult and geriatric population in a skilled nursing facility. Patients presented with a variety of diagnoses including post-surgical care, orthopedic injuries, stroke, ALS, Guillain-Barre syndrome, balance impairments, Parkinson's disease, Alzheimer's disease, and general deconditioning.

Select Physical Therapy, Henderson, NV, July-Aug 2013
Evaluation and treatment of patients with musculoskeletal conditions. Developed work hardening programs and performed functional capacity evaluations to provide return

to work capabilities and ability levels for liability cases using appropriate medical standards.

PROFESSIONAL DEVELOPMENT

APTA member, research and orthopedic sections, 2012 - present

APTA Combined Sections Attendee, 2013-2014

UNLV distinguished Lecture Series, 2012-2014

Interprofressional Seminar Series for University of Nevada Healthcare Students, 2013