5-1-2016

# Preventing Non-Contact ACL Injuries in Female Athletes: What Can We Learn from the Dancers?

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# PREVENTING NON-CONTACT ACL INJURIES IN FEMALE ATHLETES: WHAT CAN WE LEARN FROM THE DANCERS?

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

Doctor of Physical Therapy

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

University of Nevada, Las Vegas
May 2016

UNLV | GRADUATE COLLEGE

## Doctoral Project Approval

The Graduate College
The University of Nevada, Las Vegas

May 13, 2016

This doctoral project prepared by

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entitled

Preventing Non-Contact ACL Injuries in Female Athletes: What Can We Learn from the Dancers?

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

Doctor of Physical Therapy
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## ABSTRACT

**Study design**: Cross-sectional case control.

**Objectives**: The purpose of this study was to investigate the effects of dance experience and movement instruction on lower extremity kinematics and muscle activation during landing tasks

**Background/Aim**: Current research demonstrates that dancers exhibit a much lower incidence of ACL injuries when compared to athletes of other sports despite the fact that dancers jump and land frequently in their training and performance. The mechanism that underlies this disparity is unclear.

**Methods:** We analyzed lower extremity biomechanics during landing in 27 subjects (age 18-25 years, 12 dancers and 15 non-dancers). In the non-instructed (NI) conditions, participants were shown a video in which a successful landing was demonstrated. They were then shown the same videos with specific verbal instructions (VI) on how to perform the landings. Surface electromyography (EMG) was used to measure the activation of gluteus maximus and medius during the deceleration phase of landings. Peak hip knee and hip frontal plane angles were acquired using a 3-D motion capture system. Two-way mixed measures ANOVAs were used to assess the effects of group (dancers vs. non-dancers) and instruction (NI vs. VI) on the biomechanical variables.

**Results:** During landings, dancers demonstrated greater gluteus maximus activation and maintained generally more neutral hip and knee alignments when compared to non-dancers. A significant interaction showed that instruction led to increased knee valgus angle in non-dancers but not dancers.

**Conclusions:** Our findings suggested that dance training experience may lead to safer landing mechanics. Specific acute movement instruction can potentially deteriorate the mechanics of those with no dance training experience.

KEYWORDS: ACL injury, dancers, female athletes, landing, instruction

## 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 for his help and the UNLV department of Kinesiology for allowing us to use the lab. Thank you to Ron Garcia for his help with data processing. We would like to acknowledge and thank the members of the class of 2015, Brittany Keating, Jason Pyfer, and Kimberly Vialpando, for their contributions to this study. Lastly we would like to thank the UNLV department of Physical Therapy faculty for their mentorship through this process.

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## INTRODUCTION

Female athletic participation has increased over the past decade, along with a disproportionate prevalence of knee injuries in comparison to male athletes.[7] The anterior cruciate ligament (ACL) accounts for 20% of all athletic knee injuries.[21] When comparing male and female athletes participating in soccer and basketball, female athletes experience ACL injuries 3 to 4 times more frequently, with reportedly 63-80% of injuries defined as non-contact.[5] Several theories have been proposed to explain the prevalence of non-contact ACL injuries,[6] and the prevalence of ACL injuries in female athletes.[9, 14, 35, 37] Currently, a growing body of evidence suggests neuromuscular re-education and movement training may be effective for preventing ACL injury during athletic participation.[3, 9, 10]

When specifically examining gender, female soccer players injure their ACLs at an incidence rate of 0.006 to 3.7 per 1000 hours of participation[2] and female basketball players sustain ACL injuries at an incidence of 0.29 per 1000 hours.[5] In comparison, female dancers reportedly have a very low ACL injury rate of 0.0009 per 1000 exposures (defined as participation in a class, rehearsal or performance).[20] This data suggests a significantly lower risk of ACL injury, and very few studies have addressed why such a disparity between dancers and athletes might exist. Formal dance training focuses on the alignment of the body and lower extremities in aesthetically pleasing positions requiring a high level of neuromuscular control and balance. A typical 1.5 hour ballet class will often incorporate more than 200 jumps, with greater than 50% involving single-leg landings.[20] Within ballet training, external rotation of the hips is a fundamental component of technique. As a result of this training, one could theorize that dancers may activate their gluteal muscles more than other athletes during jumping and landing. As gluteus maximus is involved in generating hip abduction, extension, and external rotation movements,[11] the activation of this important and powerful gluteal muscle may be ACL protective in dancers. Through the extensive feedback and movement instruction during training, dancers may also develop heightened body awareness and controlled movement patterns when compared to other athletes. These effects were theorized to contribute to the clinically observed reduction of non-contact ACL injury risk in dancers.[20] However, the underlying biomechanical mechanism is currently unknown.

The purpose of this study was to compare lower extremity kinematics and activation of the gluteal muscles during drop landings between college-aged dancers and non-dancers, and investigate the effects of movement instruction on landing strategy. We hypothesized that dancers will land with less knee valgus, hip adduction, and greater activation of the gluteus medius and gluteus maximus muscles in comparison to non-dancers. We further hypothesized that specific movement instructions can help reduce knee valgus and hip adduction during landing.

## METHODS

### Subjects

All participants were female between the ages of 18 and 25 (12 dancers and 15 non-dancers). Only young active females were investigated due to this population's higher reported risk of ACL injury.[13, 20]. The age of the participants was matched.[24] The inclusion criteria for the dancer group was that the participants must have a minimum of 7 years of dance experience and currently train for a minimum of 12 hours per week.[34] Participants in the non-dancer group must be physically active and exercise at least 2-3 times per week for a minimum of 30 minutes per session. The exercise intensity must be in the range from moderate (3-6 METs) to vigorous (>6

METs), which is an equivalent to various forms of dancing.[1] Participants were excluded from this study if they had sustained any lower extremity injury within the past six months.[5, 8] Lower extremity injuries that occurred more than 6 months prior to data collection and were currently asymptomatic did not constitute exclusion.[31, 34] Non-dancers were also excluded from the study if they had received any formal dance training within the past 10 years.

**Instrumentation**

Hip muscle strength was measured using a handheld dynamometer (MicroFET2, Hoggan Scientific, Salt Lake City, UT, USA). Hip external rotation range of motion was measured using a standard goniometer. Gluteus maximus and gluteus medius activation were assessed using a wireless surface electromyography (EMG) system (Delsys Inc., Natick, MA, USA) with a sampling rate of 2000 Hz. Lower extremity 3D kinematic data was assessed using a 3D motion capturing system (Vicon Motion Systems Ltd., Oxford, UK) with a sampling rate of 200 Hz. A force platform (Kistler) was used to detect the instant of ground contact during the landing trials. The sampling rate was 2000 Hz. All systems were time synchronized.

**Procedures**

Prior to data collection, an informed consent approved by the University of Nevada, Las Vegas Institutional Review Board, was signed and collected from each participant. After enrollment, the participants were asked to complete a demographic and physical activity survey. The data collection procedures were outlined in Figure 1.

**Preparation of Muscle Activation Assessment**

Neuromuscular activation levels of the right gluteus maximus and gluteus medius were assessed. Skin surfaces of the muscles were cleaned and lightly abraded. Self-adhesive wireless surface EMG electrodes were attached to the skin surface. For gluteus maximus, surface electrode was placed lateral to the sacrum on the prominence of the muscle belly, in parallel to the muscle fibers. EMG signal quality was confirmed by asking the participant in a prone posture to contract the hip extensor muscle with the knee flexed. For gluteus medius, the greater trochanter was palpated and then EMG electrode was placed along the line formed by iliac crest and greater trochanter on the prominence of the muscle belly. EMG signal quality was confirmed by asking the participant to contract the hip abductor muscles by lifting their leg up in a side-lying position. The EMG electrodes were further secured with additional adhesive tape to decrease excess motion and improve surface contact of the electrodes during activity.

Once electrodes were secured, maximal voluntary isometric contraction (MVIC) testing was performed to measure the strengths of hip abduction and hip extension and establish the peak activation level. Hip abduction strength was assessed as described by Leetun et al. (Figure 2).[19] Hip extension strength was assessed as described by Stearns et al. (Figure 3).[33] In a 5-second duration, participants were asked to generate the maximal contraction isometrically. Three trials were collected for each assessment. After the strength assessments, reflective markers were placed on the participant based on the Vicon Plug-in Gait full-body marker set. A static calibration trial that acquires the body geometry and marker placements was collected followed by a five-minute warm up on an elliptical machine to familiarize the participant with performing physical activity with the attached instruments.

**Biomechanical Evaluation of Drop Landing**

Participants performed the drop landings from the top of a 30.5 cm box.[8, 25, 36] All participants performed the test conditions with bare feet.[4, 32] Participants were expected to perform drop landings with legs in a neutral and a turned-out position, with and without specific movement instructions (no instruction [NI] vs. verbal instruction [VI]). In the NI conditions, participants were shown videos of the drop landing movement demonstrated by one of the investigators.[4] Participants were not given any verbal instruction or feedback but were allowed to practice at most 3 times before performing 3 captured landing trials.[36] After completing the NI landings, participants watched the same demonstration videos but now with specific verbal instructions on how to perform the landings. The instructions focused on the positions of the body segments (i.e. trunk, hips, knees, and feet) during landing. Complete instructions can be found in Table 1. In this condition, the participants were allowed unlimited practice jumps and were given feedback by investigators on their movements during the practice, before 3 landing trials were captured.

**Data Analysis**

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

**Statistical Analysis**

Demographic information of the participants was compared using independent t-tests, specifically comparing age, height, weight, BMI, and hip abduction and extension strength between groups. Two-way mixed ANOVAs were used to investigate the effects of group (dancers vs. non-dancers) and instruction (NI vs. VI, repeat-measure factor) on the lower extremity biomechanics and hip muscle activation levels during landings. The neutral and turned-out landings were analyzed separately. When significant main effects or interactions were found, post-hoc comparisons with Bonferroni correction were performed. All analyses were done using a statistical software (SPSS version 22, IBM Corp. Armonk, NY, USA). Significance level was set at 0.05.

**RESULTS**

Independent t-tests revealed no significant differences in height, weight, BMI, hip abduction and extension strength between the dancer and non-dancer groups (Table2).

The 2-way ANOVAs for neutral landings revealed that dancers demonstrated strong trends of having greater gluteus maximus contraction and smaller knee valgus angle (gluteus maximus activation: dancers=53.8±43.3 % vs. non-dancers=28.0±21.2 %, p=0.050; peak knee valgus angle: dancers=5.3±3.2˚, non-dancers=8.1±4.1˚, p=0.055). No significant difference between groups were found in gluteus medius activation and hip adduction angle (p=0.309 and 0.431, respectively; Figure 4).

In neutral landing, a significant main effect of instruction was detected for peak knee and hip angles across groups (knee valgus angle: before instruction=6.3±3.8˚, after instruction=7.4±4.1˚, p=0.003; hip adduction angle: before instruction=-3.1±3.8˚, after instruction=-4.6±4.0˚, p=0.001). There was a significant interaction between instruction and group for knee valgus angle (p=0.014; Figure 5). The post-hoc analyses showed that within the non-dancer group, there was a significant difference in knee valgus angle before and after instruction (NI vs. VI, 7.3±3.9 ˚ vs. 9.0±4.3˚, p<0.001), but not in the dancers (NI vs. VI, 5.2±3.6˚ vs. 5.4±3.0˚, p=0.728).

The 2-way ANOVAs for turned-out landings revealed that dancers had significantly greater gluteus maximus activation and significantly smaller knee frontal angle than non-dancers ((% gluteus maximus activation: dancers=52.9±32.2 % vs. non-dancers=33.6±16.8 %, p=0.044; Knee valgus angle: dancers=8.0 ±3.2˚ vs. non-dancers=11.8±4.5˚, p=0.017; Figure 6).

A significant main effect of instruction was detected for peak knee and hip angles across groups (knee valgus angle: before instruction=9.2±4.3˚ vs. after instruction=11.0±4.4˚, p=0.001; hip adduction angle: no instruction=-11.1±3.4˚ vs. instruction=-12.5±3.3˚, p=0.006). There were no significant interactions between instruction and group on any of the variables in this landing condition.

## DISCUSSION

Our primary finding was that dancers in general exhibited a smaller knee valgus angle and greater gluteus maximus activation during drop landing tasks when compared to non-dancers. Additionally, there was a difference in how dancers and non-dancers reacted to movement instructions during the neutral drop landing task. After instructions, we observed an increase in the non-dancer's knee valgus angle while dancer's knee angle did not change significantly.

### Gluteus Maximus Activation

Preventing ACL injuries is a top priority in female youth sports. The effectiveness of specific movement training programs designed to address this concern has been demonstrated,[3, 28, 30] and commonly focus on tasks requiring gluteus maximus activation during landing and deceleration. The extensive training dancers receive in a turned-out position may increase their ability to engage the gluteus maximus muscles during the deceleration phase of landing. Increased gluteus maximus activation may also lead to a decreased knee frontal angle on landing as a result of greater femoral rotation control.[15] This theory was supported by our data that the dancers exhibited on average 20-25% greater gluteus maximus activation and a corresponding smaller knee valgus angle during the deceleration phase of landing when compared to non-dancers. With excessive knee valgus angle being a factor for knee ligamentous injuries, the dancers appeared to be employing a protective landing strategy, potentially explaining the lower rate of ACL injuries within this population.

We observed peak knee valgus angle to occur within 100 ms after ground contact. Previous video analysis of ACL injuries suggests that injurious incidences typically occur 17-50 ms after ground contact.[18] Because the knee is most vulnerable to ligamentous injuries so quickly after contact, a person is unlikely to use feedback response to correct the knee motions. A feed-forward motor planning that pre-aligns the lower extremity prior to landing would be far more efficient and protective during high velocity loading and impact activities. However, in this study, the differences in peak knee valgus angle were less than 4° between the dancers and non-dancers. The bilateral drop landing task utilized does not challenge the femoral control as much as a single-leg landing, and we might have observed greater knee valgus if a more challenging single leg task was used.[29] However, Orishimo et al. found no difference between professional male and female dancers in performance of a single-legged drop landing, and subsequently demonstrated female sports athletes landing with greater peak knee valgus in comparison to both genders of dancers during the same task.[25, 26] Again, in our study, it was revealing that the dancers landed with the knee in a more neutral alignment when compared to the non-dancers. This may indicate a higher level of joint kinesthetic awareness and femoral control from increased gluteus maximus activation as a consequence of dance training.

**Movement Instruction**

The addition of verbal instructions in this study resulted in a small but significant increase in the knee valgus angle. This was unexpected as explicit instruction: "…do not let your knees fall in toward each other when landing" was included in the cuing. Conversely, we observed a general reduction of hip adduction angle in the landing trials following instruction. The significant interaction between group and instruction during landing in the neutral position demonstrated no significant changes in knee valgus angle for the dancers, while the non-dancers showed significant increases. This potentially indicated different interpretation and processing of the verbal movement instruction by the dancers and non-dancers.

Our specific verbal movement instructions may have negatively influenced the landing mechanics as the cues were primarily focused internally on body alignment. While such instructions have been commonly used in ACL injury prevention programs,[23] the internal attentional focus may interfere with movement performance. A number of previous studies have demonstrated the negative influence of internal attentional focus and excessive instruction on motor learning and performance.[38, 39] This may explain why some ACL injury prevention programs were not effective.[27] However, dancers are used to receiving a combination of internally and externally focused instruction which may account for the lack of performance degradation. Research has suggested, that the enhanced proprioception documented in dancers provides them with the ability to shift their attentional focus away from basic tasks in order to focus on the execution of more challenging tasks.[17] Therefore, one might argue that the basic landing activity required during this study was a task the dancers were already skilled in performing and consequently uninfluenced by the verbal instructions.

A number of authors have questioned whether or not dancers possess enhanced proprioception, motor control and coordination as a result of their training, or if individuals with enhanced abilities are more likely to become dancers?[16, 17] There is likely an argument for a combination of both. Marmeleira et al. demonstrated improved knee joint position sense and knee kinesthesia following a 12 week creative dancing program for older adults suggesting training programs may be beneficial in enhancing lower limb proprioception regardless of age and experience.[22] Based on our study, we suggest future research should look at multiple factors in the design of ACL injury prevention programs including focusing on enhancing proprioception of the entire lower kinetic chain, the effect of internal versus external attentional focus and prior training experience on the biomechanics of landing. Currently published research suggests external attentional focus is beneficial in improving movement patterns to reduce second ACL injury risk following ACL reconstruction,[12] however, could there be a role for a combination of both internal and external cuing based on the motor learning stage of the participant? Screening for the existence of enhanced proprioception prior to participation in an at-risk sport might also be relevant in decreasing the frequency of ACL injury. One might also question if the inclusion of specific jump training focusing on lower extremity alignment, technique and gluteus maximus activation, as dancers typically do from an early age, would have a role in diminishing ACL injury rates if integrated into injury prevention programs at an earlier age for at-risk athletes?

This study has a number of limitations. The dancers were recruited from the Dance Department of a university, and therefore typically had a higher activity levels compared to non-dancers who were mostly recreationally active. The dancers had mixed training backgrounds including both modern and ballet. Furthermore, we only observed the acute effects of instruction on landing mechanics; it was unknown if the same effects would be observed if the participants had more time to practice the landing movements as in a typical ACL injury prevention program. Biomechanical comparison of dancers versus other high level athletes would help elucidate the influence of training experience on landing mechanics.

## CONCLUSION

This study demonstrates that during landing dancers employed movement and neuromuscular control strategies that were different from non-dancers. Specifically dancers exhibited increased activation of the gluteus maximus and a reduction of knee valgus angle, potentially protective attributes against non-contact ACL injuries. Verbal instructions had an acute effect on landing mechanics, and this effect can be negative for non-dancers. Results of this study provided insight into the observed lower rate of ACL injuries in dancers and may provide argument for incorporating dance education concepts into ACL injury prevention programs. However, future research should investigate the most beneficial forms of cuing, and the optimal developmental motor learning period to initiate protective training strategies for the ACL.

**APPENDIX**

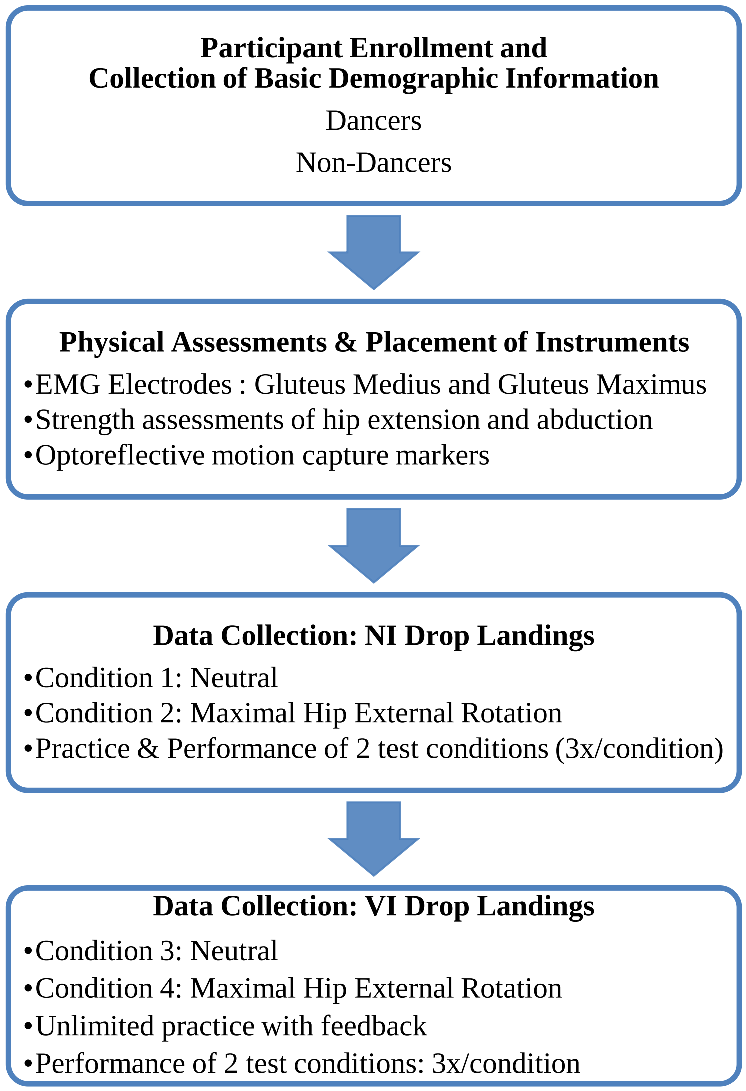
**TABLE 1**: Instructions given to the participants for each test condition.

| Test conditions: | Instructions given: |
|---|---|
| Drop landing in neutral | 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 step off the box and land on the ground in the same position you started in. 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. |
| Drop landing in maximal 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 step 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 2. 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. |
| *For all jump conditions, participants were instructed to keep their hands on their hips at all times and to keep their eyes looking forward. | |

**TABLE 2**. Demographic and Anthropometric Information of the Participants.

| | Dancer N=(12) | Non-Dancer N=(15) | **P-value** |
|---|---|---|---|
| Age (yrs) | 20.58±1.13 | 22.07±1.68 | **0.039** |
| Height (m) | 1.65±0.06 | 1.62±0.07 | **0.201** |
| Weight (kg) | 60.88±6.01 | 58.77±6.51 | **0.395** |
| BMI ($kg/m^2$) | 22.36±2.34 | 22.45±2.25 | **0.981** |
| Hip Abduction Strength (N) | 57.69±11.55 | 53.89±11.27 | **0.397** |
| Hip Extension Strength (N) | 101.39±26.93 | 101.33±26.48 | **0.995** |

**FIGURE 1**: Experimental Procedures Overview




*Abbreviations: NI, no instructions; VI, verbal instructions.*

**FIGURE 2**: Isometric Hip Abduction Strength Testing

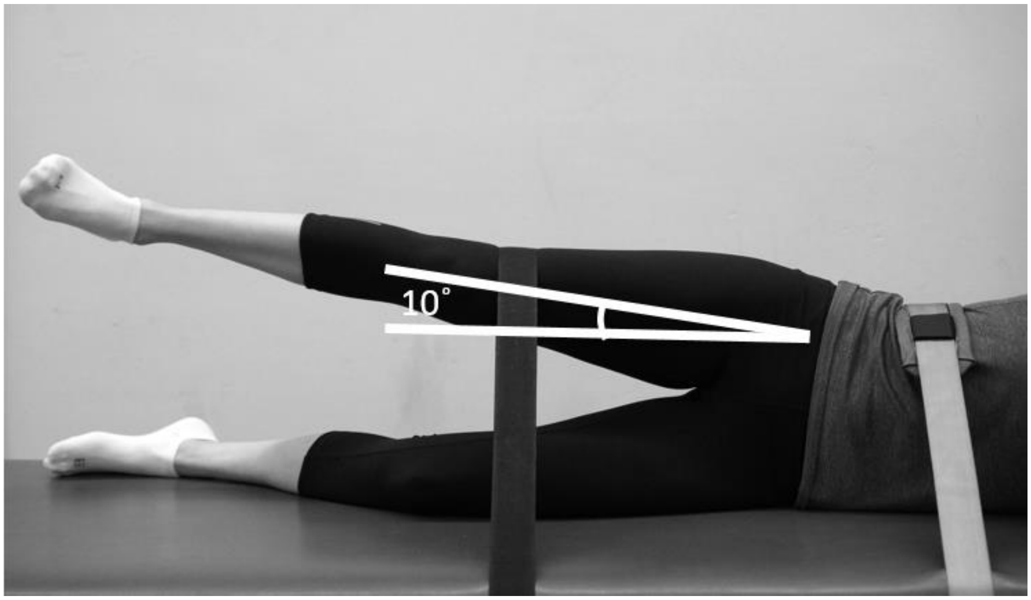



**FIGURE 3**: Isometric Hip Extension Strength Testing

**FIGURE 4:** Comparison of Frontal Plane Hip and Knee Mechanics and Muscle Activation between Non-Dancers and Dancers in Neutral Drop Landing

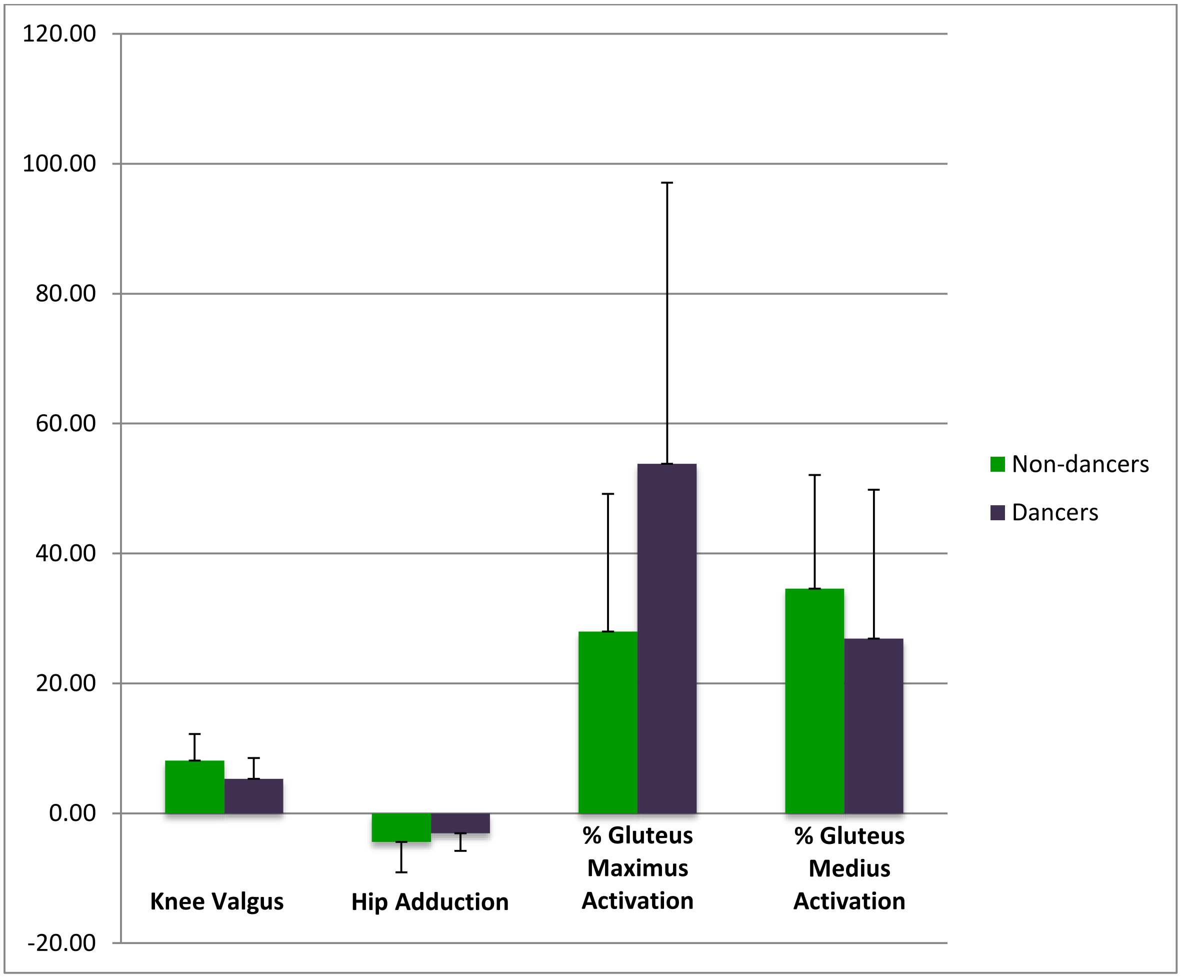


**FIGURE 5**: Knee Valgus Angle Group by Condition Interaction in Neutral Drop Landing

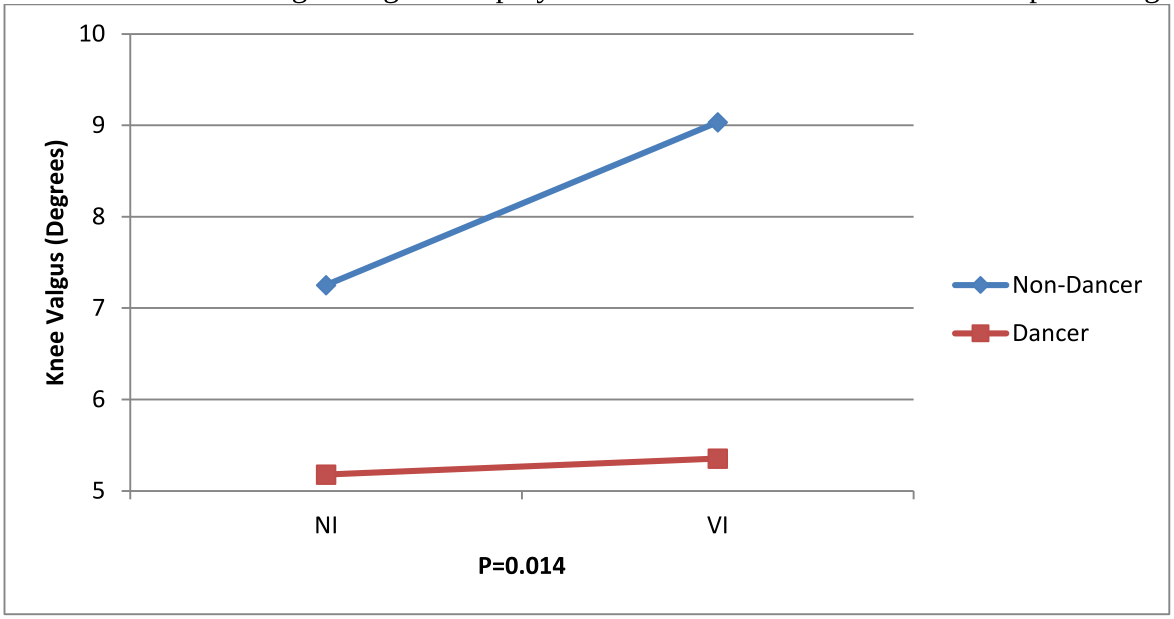
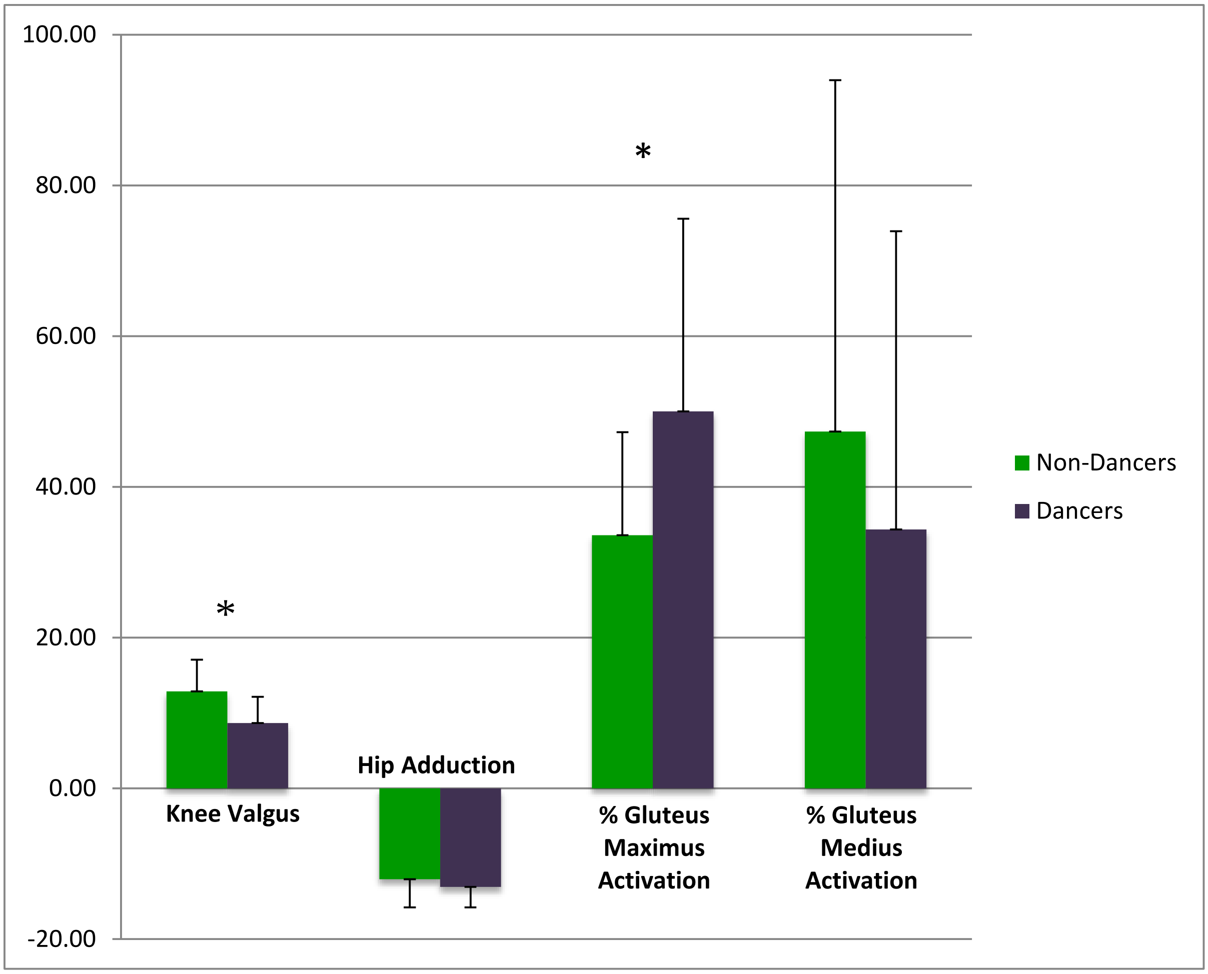


**FIGURE 6**: Comparison of Frontal Plane Hip and Knee Mechanics and Muscle Activation between Non-Dancers and Dancers in Turned-Out Drop Landing



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## CURRICULUM VITAE


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## EDUCATION:

University of Nevada, Las Vegas

- Doctor of Physical Therapy, May 2016

University of Washington, Seattle

- Bachelor of Arts in Communication, June 2012

## CLINICAL EXPERIENCE:

Multicare Mary Bridge Children's Therapy Unit – Puyallup, WA – January 2016-April 2016

- Outpatient Pediatric Physical Therapy: Supervised full time extended clinical learning experience 12 weeks in duration

Tacoma Lutheran Retirement Community –Tacoma, WA – October 2015-December 2015

- Skilled Nursing Facility: Supervised full time extended clinical learning experience 10.5 weeks in duration

Providence St. Peter's Hospital – Olympia, WA – July 2015-September 2015

- Acute Inpatient Physical Therapy: Supervised full time extended clinical learning experience 11 weeks in duration

MVP Physical Therapy – Lakewood, WA – June 2014-August 2014

- Outpatient Physical Therapy: Supervised full time extended clinical learning experience 6 weeks in duration

**RESEARCH IN PROGRESS:**

- Turner C, Lee SP, Crow S, Crowther T, Keating B, Pyfer J, Saupan T, Vialpando K. Preventing Non-contact ACL Injuries in Female Athletes: What Can We Learn from the Dancers?

**PROFESSIONAL MEMBERSHIP/CERTIFICATIONS:**

- American Physical Therapy Association, Nevada & Washington State Chapter: 2013-Present
- American Heart Association Healthcare Provider CPR and AED Certification: 2015-present

**SUPPLEMENTAL EDUCATION:**

- Changing Problem Behaviors: Strategies for Parenting with Kids with Developmental Differences – Parents Course: Tonya Kellerman, Ph.D., February 2016
- Use of the DIR®/Floortime™ Model for Children with Special Needs – Parents Course: Dawn Heino, OTR/L, January 2016
- Washington: HIV/AIDS Continuing Education, 7 units, January, 2016
- UNLV Physical Therapy Research Presentations, May 2015
- Therapeutic Neuroscience Education: Dr. Adriaan Louw, April 2015
- UNLV Physical Therapy Research Presentations: May 2014
- UNLVPT Distinguished Lecture Series: Dr. Timothy W. Flynn, November 2014
- HIPAA Training.  March 2014
- Combined Sections Meeting of APTA, Las Vegas; February 2014
- UNLVPT Distinguished Lecture Series: Dr. Gail Jensen, June 2013

**REFERENCES:**

- References available upon request

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**EDUCATION:**

University of Nevada, Las Vegas

- Doctor of Physical Therapy, May 2016

University of Nevada, Reno

- Bachelor of Science in Biology, May 2012

**CLINICAL EXPERIENCE:**

VA Sierra Nevada Health Care System: Reno, NV February 2016-April 2016

- Inpatient Rehabilitation: Perform evaluations, treatments, reevaluations and discharges
- Experience with patients with debility, orthopedic injury/surgery, neurological events, dementia and cancer
- Frequent interdisciplinary communication, daily billing and documentation

VA Sierra Nevada Health Care System: Reno, NV December 2015-February 2016

- Acute Inpatient Physical Therapy: Perform evaluations, treatments, reevaluations and discharge planning
- Diverse patient population including orthopedics, debility, acute illness, neurological and cardiac
- Frequent interdisciplinary communication, daily billing and documentation

Advanced Pediatric Therapies: Sparks, NV October 2015-December 2015

- Outpatient Pediatric Physical Therapy: Evaluations, treatments, reevaluations and discharges
- Variety of patients including sensory processing disorders, genetic abnormalities, neurological impairments, orthopedics
- Various assessment tools: PDMS-2, DAYC-2, HELP, BOT, BDI-2

St. Rose Dominican, Siena Campus: Las Vegas, NV July 2015-September 2015

- Acute Inpatient Physical Therapy: Evaluations, treatments and reevaluations
- Primary focus of post-op day 0 total hip and total knee replacements
- Daily billing, documentation, care planning and goal setting

Elevate Physical Therapy: Orem, UT June 2014-August 2014

- Initial evaluations, reevaluations and discharges for orthopedic patients
- Skilled interventions: Manual therapy, therapeutic exercise, therapeutic activity, neuro-reeducation, gait training, aquatic therapy
- Daily billing, documentation, care planning and goal setting

**RESEARCH IN PROGRESS:**

- Turner C, Lee SP, Crow S, Crowther T, Keating B, Pyfer J, Saupan T, Vialpando K. Preventing Non-contact ACL Injuries in Female Athletes: What Can We Learn from the Dancers?

**PROFESSIONAL MEMBERSHIP/CERTIFICATIONS:**

- American Physical Therapy Association, Nevada Chapter: 2013-Present
- American Heart Association Healthcare Provider CPR and AED Certification: 2015-present

**SUPPLEMENTAL EDUCATION:**

- HIPPA Training, November 2015
- Therapeutic Neuroscience Education: Dr. Adriaan Louw, April 2015
- UNLV Physical Therapy Research Presentations: May 2014
- UNLVPT Distinguished Lecture Series: Dr. Timothy W. Flynn, November 2014
- Combined Sections Meeting of APTA, Las Vegas; February 2014
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**REFERENCES:**

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## EDUCATION:

University of Nevada, Las Vegas

- Doctor of Physical Therapy, May 2016

University of Utah

- Bachelor of Science in Economics, August 2011

## CLINICAL EXPERIENCE:

VA Southern Nevada Healthcare System**:** Las Vegas, NV January 2016- April 2016

- Acute care rehabilitation

Elam Sports O'ahu: Kapolei, HI October 2015- December 2015

- Outpatient orthopedic rehabilitation

Aspen Ridge Transitional Rehab: Murray, UT July 2015- September 2015

- Inpatient rehabilitation

Achieve Physical Therapy: Henderson, NV June 2014- August 2014

- Outpatient orthopedic rehabilitation

## RESEARCH IN PROGRESS:

- Turner C, Lee SP, Crow S, Crowther T, Keating B, Pyfer J, Saupan T, Vialpando K. Preventing Non-contact ACL Injuries in Female Athletes: What Can We Learn from the Dancers?

## PROFESSIONAL MEMBERSHIP/CERTIFICATIONS:

- American Physical Therapy Association (APTA) 2013-present
- American Heart Association Healthcare Provider CPR and AED Certification 2010-present

## SUPPLEMENTAL EDUCATION:

- Combined Sections Meeting of APTA; 2016 Anaheim, CA
- HIPAA Training, December 2015
- UNLV Physical Therapy Research Presentations, May 2015
- Therapeutic Neuroscience Education: Dr. Adriaan Louw, April 2015

- DBS Therapy for Parkinson's Disease: Dr. Eric S. Farbman, March 2015
- UNLV Physical Therapy Research Presentations, May 2014
- UNLVPT Distinguished Lecture Series: Dr. Timothy W. Flynn, November 2014
- Combined Sections Meeting of APTA; 2014 Las Vegas, NV
- HIPAA Training.  March 2014
- UNLVPT Distinguished Lecture Series: Dr. Gail Jensen. June 2013

**REFERENCES:**

- References available upon request