5-2020

Electromyographic Activity of Hip Abductor Muscle during Jumping and Landing: Pilot Study

Chloe Coleman
University of North Dakota

Jairica Christjohn
University of North Dakota

Ryan Keller
University of North Dakota

Carly Jo Schroer
University of North Dakota

ELECTROMYOGRAPHIC ACTIVITY OF HIP ABDUCTOR MUSCLE DURING JUMPING AND LANDING: PILOT STUDY

by

Chloe Coleman, SPT
Bachelor of Science in Psychology
University of North Dakota, 2017

Jairica Christjohn, SPT
Associate in Liberal Arts
North Dakota State College of Science, 2016

Ryan Keller, SPT
Bachelor of Science with emphasis in Health Science
University of North Dakota, 2018

Carly Jo Schroer, SPT
Bachelor of Science in Kinesiology
University of North Dakota, 2017

A Scholarly Project Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

University of North Dakota

in partial fulfillment of the requirements for the degree of

Doctor of Physical Therapy

Grand Forks, North Dakota
May, 2020

This Scholarly Project, submitted by Jairica Christjohn, Chloe Coleman, Ryan Keller, and Carly Jo Schroer in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Graduate School Advisor)

(Chairperson, Physical Therapy)

PERMISSION

Title Electromyographic Activity of Hip Abductor Muscle During Jumping and Landing: Pilot Study

Department Physical Therapy

Degree Doctor of Physical Therapy

In presenting this Scholarly Project in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in his absence, by the Chairperson of the department. It is understood that any copying or publication or other use of this Scholarly Project or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in this Scholarly Project.

Signature Chloe Coleman
CJ Schwer
Ryan Keller
Janice Christy

Date 11/13/19

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Background and Purpose: The purpose of this study was to see if there is a difference in the electromyographic (EMG) activity in the hip abductor muscles (right gluteus medius) with regard to knee valgus in free standing vertical jump and landing. Both male and female participants were analyzed.

Methods: Six subjects (2 male, 4 female) in good physical condition with no previous knee pathologies participated in the experiment. EMG activity was recorded using a Noraxon TeleMyo DTS telemetry unit with a sampling rate of 1 kHz. The EMG data for the gluteus medius muscle activity and knee valgus was recorded during the three jumps which participants took off with both legs and landed on the right leg at a distance of 30% of their height. The subject was also captured on video a NiNox 125/250 camera system. The video camera was synced to the EMG data collection. The muscle tested was the right gluteus medius muscle on all subjects.

Results: The results of this study showed that Gluteus Medius activation was greater in males compared to females, however there was only a small difference between the mean and maximum knee valgus values between males and females. Males demonstrated a greater range of knee valgus between participants when compared to females. Overall there was no apparent

relationship between the amount of knee valgus and the %MVC of hip abductors between subjects.

INTRODUCTION

Background and Purpose

Previous research has found that females tend to have a higher incidence of anterior cruciate ligament (ACL) injuries when compared to males. Biomechanical and epidemiological considerations for ACL injuries found 4 neuromuscular imbalances that increase the risk for ACL injuries.[1] The imbalances included ligament dominance, quadriceps dominance, leg dominance, and trunk dominance. When taking into consideration sex differences, females are more likely to exhibit one or more of these imbalances than males. Other research articles continue to further analyze these components for not just ACL injuries but also other common knee injuries/pain such as patellofemoral pain.

Research performed by Arundale et al.[2] looked at the amount of knee valgus during single leg jumping and landing in males and females. The research used male and female soccer players and had them perform tuck jumps on a single leg while measuring the amount of knee valgus in both legs. They found that the females had higher levels of knee valgus and more technique flaws when performing the jumping activity than males. This research was found to be consistent with previous research that found females to have greater knee valgus which could be a potential cause of greater ACL tears when comparing genders.

Mirzaie et al.[3] looked at patellofemoral pain in males with a specific focus on muscle activity during single leg stance and single leg squat. They found, when compared to the control group with no patellofemoral pain, the males with patellofemoral pain had significant differences in gluteus medius and vastus medialis oblique activation in both activities. The gluteus medius and vastus medialis oblique activation appeared altered when performing single leg stance and single leg squat compared to healthy subjects along with demonstrated different muscle recruitment patterns. Wilson et al.[4] performed research on patellofemoral pain with specific regard to the increased incidence in females. The study was conducted on the gluteal muscle activity in female and male runners. They found that the females had a 40% higher gluteal muscle activation and 53% greater average activation level of gluteal musculature when compared with males. It was interpreted that increased gluteal muscle activation in females results in quicker fatigue of those muscles leading to a potential decrease in technique performance and consequential patellofemoral symptoms. This could be associated with the more frequent anterior knee pain diagnoses and neuromuscular imbalances when compared to males.

Dix et al.[5] looked at asymptomatic females and the relationship between dynamic knee valgus and hip muscle strength during dynamic tasks. In their systematic review, there was a conflicting relationship between dynamic knee valgus and hip strength when comparing previous studies. There were five studies that found no relationship between dynamic knee valgus and hip muscle strength. In a different eight studies, it was found that the amount of dynamic

knee valgus was directly related to weak hip musculature, and additional three other studies found strong hip strength to be associated with dynamic knee valgus. After reviewing conflicting system reviews, the meta-analysis found that there is a relationship between dynamic knee valgus and weak hip strength during ballistic single leg landing, but this relationship was not found during single leg squats or double leg landing. This research suggests that the relationship is dependent on the task being performed.

Research suggests that females have more ACL injuries than male. Previous studies have found multiple different reasons for this difference including fatigue, neuromuscular imbalance, muscle activation and technique. The purpose of our study was to investigate the relationship between gluteus medius activation and the amount of dynamic knee valgus during jumping and single leg landing exercises that may contribute to the increased incidence of injury. We hypothesized that females would have less gluteus medius activation leading to subsequent greater knee valgus during the activities

METHODS

EMG activity was recorded using a Noraxon TeleMyo DTS telemetry unit with a sampling rate of 1 kHz. The EMG data was recorded from the gluteus medius muscle using the Noraxon Model 546 DTS EMG sensor system which transmitted the EMG data to a Noraxon Model 580 DTS receiver connected to a laptop computer which stored the collected data. The EMG data was analyzed using the Noraxon MR3 MyoMuscle software program. The Noraxon Myovideo system, using a NiNox 125/250 camera system was used to record the knee motion. The video camera was synced to the EMG data collection.

The muscle tested was the right gluteus medius muscle on all subjects. Before applying the EMG electrodes, the skin was abraded and cleaned with isopropyl alcohol. The DTS sensors were attached to the skin using double stick tape. The electrodes were placed on the skin, parallel to the muscle fiber orientation and followed standard, recommended placement sites.[6,7] The gluteus medius EMG electrodes were placed as follows: ½ the distance from the top of the iliac crest to the greater trochanter.

A footswitch pad was placed in the right shoe of each subject to detect the times when the subject's foot left the floor and when the subject's foot first touched the floor after landing from the jump. Reflective markers were placed

over the anterior, proximal and distal femur to mark the position of the femur and on the anterior, proximal and distal tibia to mark the position of the tibia. The Noraxon software was used to draw a line between the two femoral markers and a line between the two tibial markers. Those two lines described the sides of an angle that calculated knee valgus during and after the jump activity. The Noraxon software and motion analysis were used to track the knee valgus angle during the jumping activity. The knee valgus angle, the footswitch and the EMG were all synchronized by the Noraxon MyoMuscle software program. Each subject performed three jumps with a rest period between each jump. The EMG, the footswitch activity and the knee valgus angle was recorded during the entire jump.

Before beginning the jump activities, a maximal voluntary contraction (MVC) was elicited from the gluteus medius muscle using a standard manual muscle test position. The MVC was performed to establish a normalization baseline for comparison of the individual subject's EMG activity. The subject was placed in left sidelying on a plinth. The subject was asked to abduct the hip and hold the position while the examiner applied maximal resistance for five seconds. EMG activity was collected over the five second period and was used as the MVC. The EMG activity recorded during the jump was compared to the maximal voluntary contraction and calculated as a percentage of the MVC.

Six subjects participated in the experiment. Two of the subjects were male and four of the subjects were female. All of the subjects were healthy, active college students with no prior history of knee injuries. All of the subjects

completed a Lysholm Knee Scale inventory to verify that they had no prior or present knee problems. All of the subjects signed a consent form approved by the University of North Dakota Institutional Review Board.

Data Analysis

The EMG signals were full wave rectified and smoothed using RMS averaging with a 50 millisecond window. The EMG data from the gluteus medius MVC was compared to the EMG data collected during the jumping trials. To calculate the MVC for the gluteus medius, a three second period of the five second contraction was marked in the software. The software then calculated the highest one second period of contiguous EMG activity found during that three second time period. That EMG activity was saved as the MVC value.

For the normalization, a two second time period immediately following the jump landing was marked and analyzed. The MyoMuscle software was set to identify the highest one second period of contiguous EMG activity found during the two second time period and compare that level of EMG with the level of EMG that occurred during the MVC test. The EMG activity occurring after each landing trial was compared to the activity occurring during the gluteus medius.

MVC test, and was represented as a percent of normal walking using the following formula:

$$Percent\ of\ MVC = \frac{Gluteus\ Medius\ Activity\ During\ Jumping}{Gluteus\ Medius\ Activity\ During\ MVC\ Test}$$

The resulting percent of EMG was used for all the subsequent data comparisons.

RESULTS

In single jump landing all male and female participants exhibited knee valgus. Males and females demonstrated differences in %MVC of the gluteus medius and knee valgus. The gluteus medius demonstrated a greater average %MVC in males (37.15) compared to females (34.05). Males were found to have higher average knee valgus (7.5 degrees) compared to females (4.9 degrees). The males also demonstrated a larger range of knee valgus (5.7 degrees - 9.3 degrees) compared to females (4.2 degrees- 5.4 degrees) (Figure 3).

Overall there was no apparent relationship in the amount of knee valgus when compared to the %MVC of hip abductors between subjects. The increased hip abduction muscle activity did not result in decreased knee valgus in all subjects, however when comparing males to females the male subjects had a greater knee valgus to %MVC ratio (.1945) than females (.1545).

Figure 1. Gluteus Medius Activity Following Jumping and Landing.

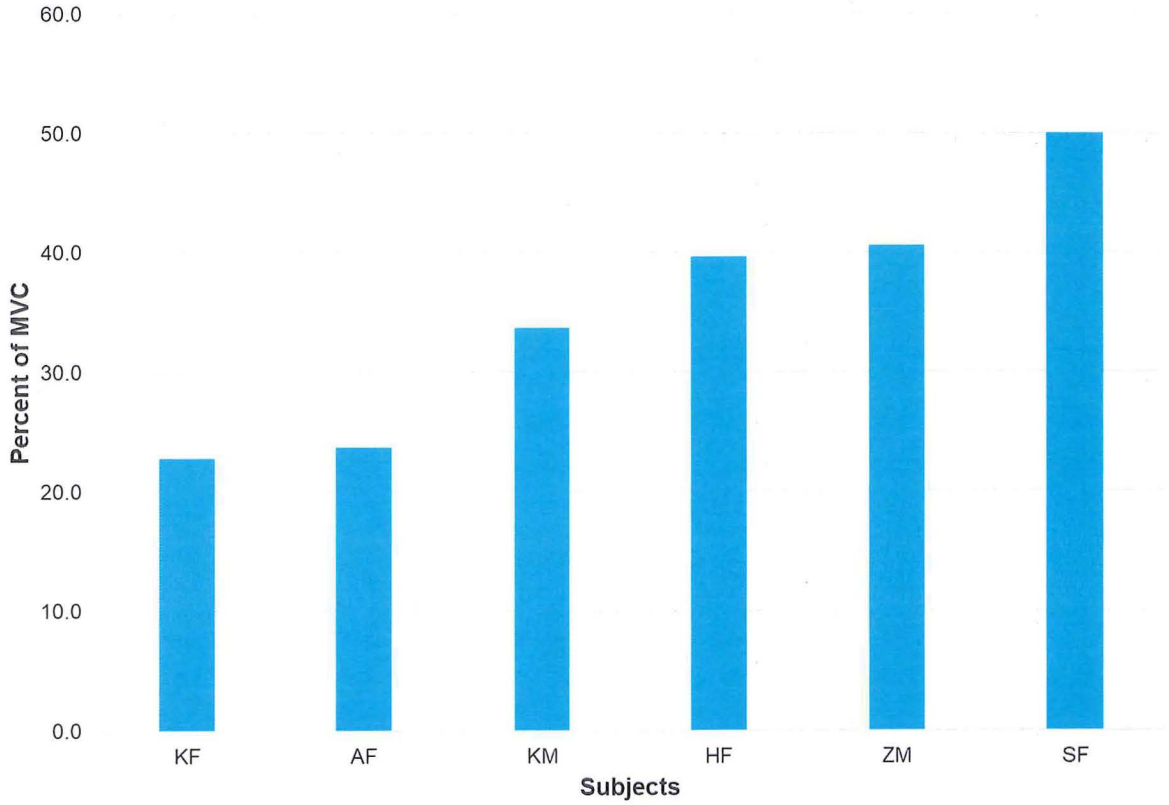


Figure 2. Knee Valgus Following Jump and Landing.

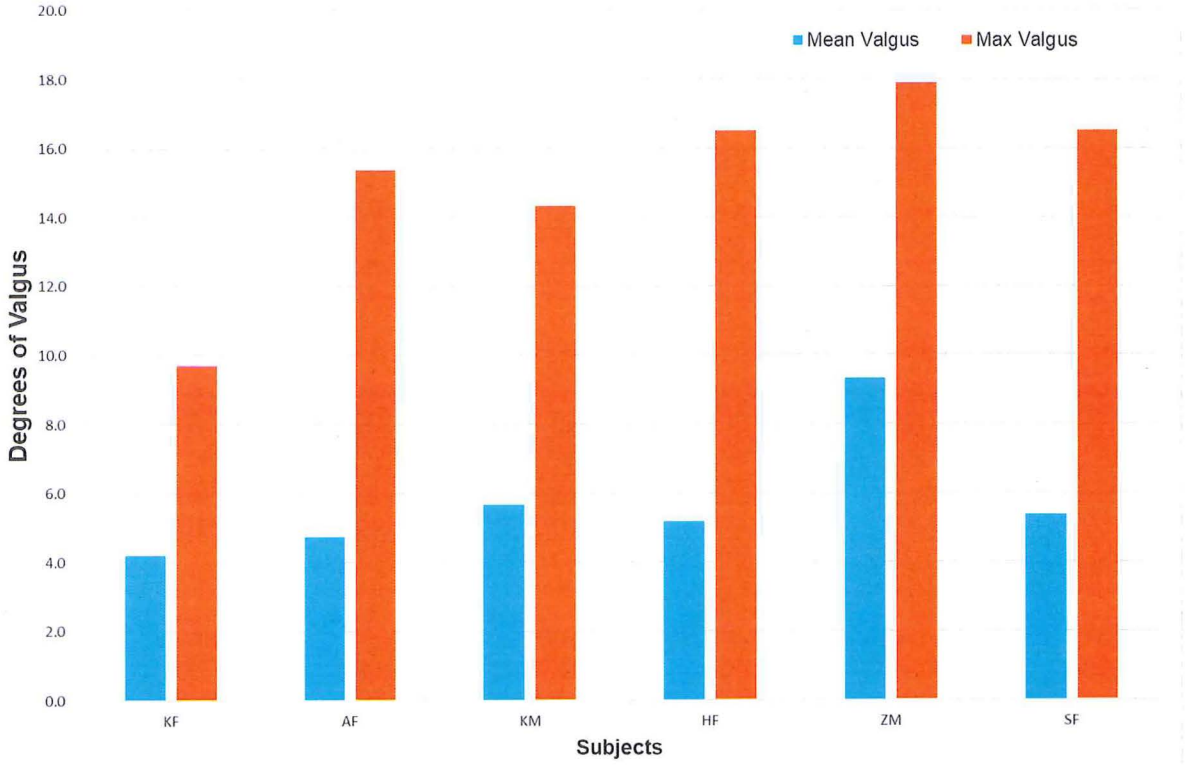
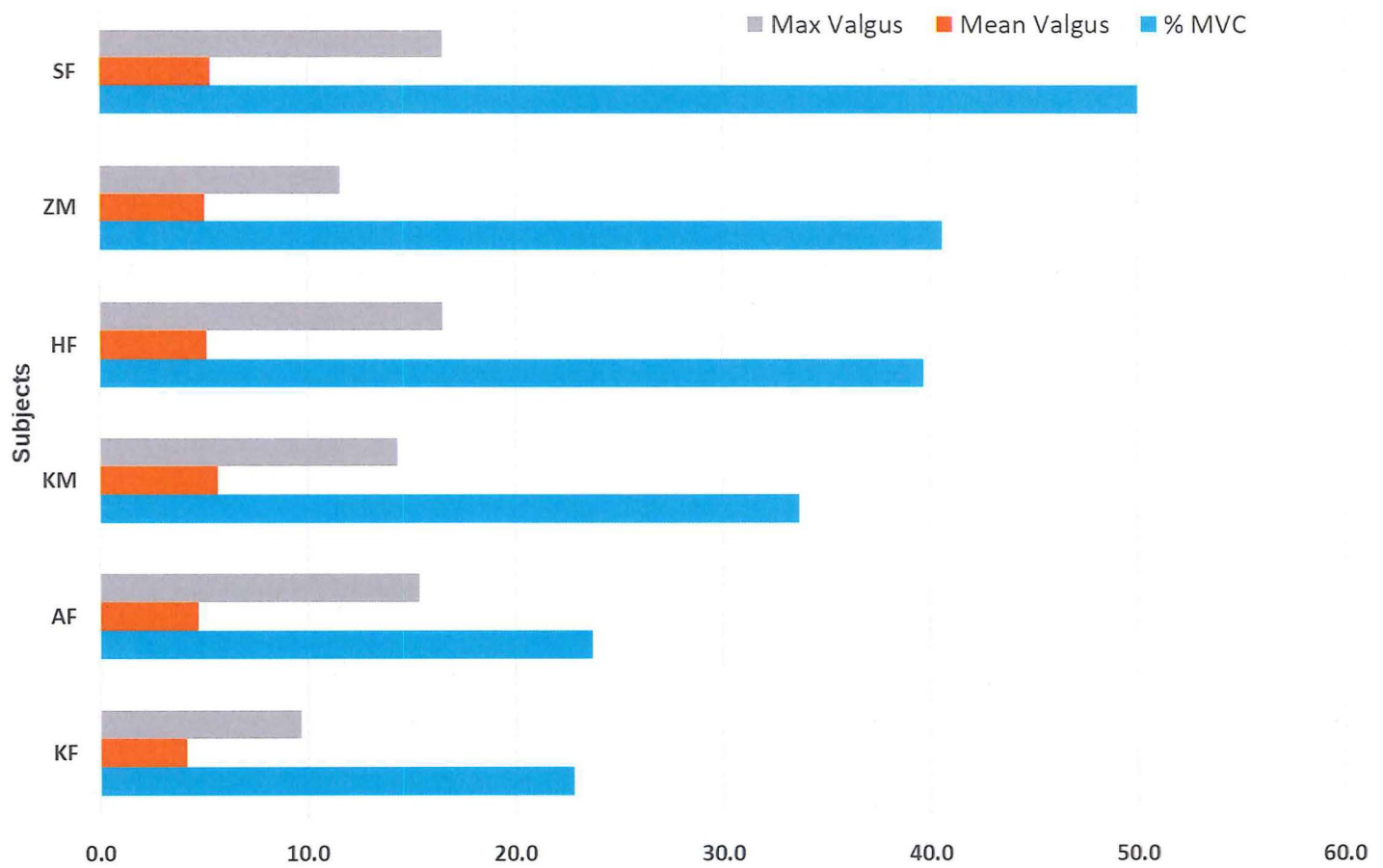


Figure 3. Gluteus Medius Activity and Knee Valgus Following Jump and Landing.



DISCUSSION

The results of this study shows some consistency with previous literature regarding hip abductor strength and knee valgus correlation between sexes.[6] That is, that hip abductor contraction does not correlate with dynamic valgus. Inconsistencies were also noted though a literature review. Multiple articles found that females tend to have a greater static q-angle and dynamic knee valgus when compared to males. Pantano et al.[7] found that pelvic width to femoral length ratios, rather than q-angle may be a better predictor of knee valgus during dynamic movement, after finding no significance in valgus between a high and low q-angle participant. Russell et al.[6] also determined that gluteus medius muscle activation did not differ between the sexes and thus does not appear to be responsible for the sex differences in knee valgus.

Limitations:

The sample size was limited to 6 participants (4 females and 2 males). Future studies should include more participants to show a better representation with adequate power to allow statistical analysis. The study did not consider athletic ability, or BMI- both factors that may have impacted results. It would also be interesting to test subjects with previous knee injury followed by extensive physical therapy. Another limitation was the instruction given to participants. They were instructed on the distance length to jump and to land on a single leg,

but not how to land, if the participants were instructed to focus on avoiding knee valgus and landing with minimal ground reaction force it may have made a difference. Many comparable studies documented static and dynamic q-angle to be included in analysis, in future studies we would also measure said values. Future studies should also look at the impact gluteus medius fatigue and the impact it has on jumping and landing technique. There is a lack of research addressing gluteus medius recruitment during jumping and landing with previous injury and knee pain.

Conclusion:

Research has shown that gluteus medius activation does not correlate to dynamic knee valgus and that females are more likely to demonstrate increase in dynamic knee valgus. Our findings did not have enough subjects to determine correlations between knee valgus and gluteus medius activation. Further research is needed to determine the impact of hip abductor strength to confirm or deny its correlation to dynamic knee valgus during jumping and landing activities. We recommend further exploration into other contributing factors to knee valgus in addition to gluteus medius activation.

REFERENCES

1. Hewett TE, Ford KR, Hoogenboom BJ, et al. Understanding and preventing ACL injuries: current biomechanical and epidemiologic considerations- update 2010. *North American Journal of Sports Physical Therapy.* 2010; 5(4): 234-251
2. Arundale AJH, Kvist J, Hägglund M, et al. Jump performance in male and female football players. *Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA.* https://www.ncbi.nlm.nih.gov/pubmed/31667569. Published October 30, 2019. Accessed November 7, 2019.
3. Mirzaie GH, Rahimi A, Kajbafavala M, et al. Electromyographic activity of the hip and knee muscles during functional tasks in males with and without patellofemoral pain. *Journal of Body movement Therapy.* 2019; 23(1): 54-58.
4. Willson JD, Petrowitz I, Butler RJ, Kernozek TW. Male and female gluteal muscle activity and lower extremity kinematics during running. *Clinical Biomechanics.* 2012;27(10):1052-1057.
5. Dix J, Marsh S, Dingenen B, Malliaras P. The relationship between hip muscle strength and dynamic knee valgus in asymptomatic females: A systematic review. *Physical Therapy in Sport.* 2019;37:197-209.

6. Russell KA, Palmier RM, Zinder SM. Sex differences in valgus knee angle during a single-leg drop jump. *Journal of Athletic Training.* 2006; 41(2): 166-171.
7. Pantano KJ, White SC, Gilchrist LA, Leddy J. Differences i peak knee valgus angles between individuals with high and low Q-angles during a single limb squat. *Clinical Biomechanics.* (2005). 20: 966-972.

Electromyographic Activity of Hip Abductor Muscle During Jumping and Landing: Pilot Study

By: Jairica Christjohn, Carly Jo Schroer, Ryan Keller, Chloe Coleman

UND School of Medicine & Health Sciences
University of North Dakota

Abstract

Background and Purpose: The purpose of this study was to see if there is a difference in the electromyographic (EMG) activity in the hip abductor muscles (right gluteus medius) with regard to knee valgus in free standing vertical jump and landing. Both male and female participants were analyzed.

Methods: Six subjects (2 male, 4 female) in good physical condition with no previous knee pathologies participated in the experiment. EMG activity was recorded using a Noraxon TeleMyo DTS telemetry unit with a sampling rate of 1 kHz. The EMG data for the gluteus medius muscle activity and knee valgus was recorded during the three jumps which participants took off with both legs and landed on the right leg at a distance of 30% of their height. The subject was also captured on video a NiNox 125/250 camera system. The video camera was synced to the EMG data collection. The muscle tested was the right gluteus medius muscle on all subjects.

Results: The results of this study showed that Gluteus Medius activation was greater in males compared to females, however there was only a small difference between the mean and maximum knee valgus values between the males and females. Males demonstrated a greater range of knee valgus between participants when compared to females. Overall there was no apparent relationship between the amount of knee valgus and the %MVC of hip abductors between subjects.

Methods

Six subjects (2 male, 4 female) participated in the experiment. All of the subjects were healthy, active college students with no prior history of knee injuries.

EMG activity was recorded using a Noraxon TeleMyo DTS telemetry unit with a sampling rate of 1 kHz. The EMG data was recorded from the gluteus medius muscle using the Noraxon Model 546 DTS EMG sensor system which transmitted the EMG data to a Noraxon Model 580 DTS receiver connected to a laptop computer which stored the collected data. The EMG data was analyzed using the Noraxon MR3 MyoMuscle software program. The Noraxon Myovideo system, using a NiNox 125/250 camera system was used to record the knee motion. The video camera was synced to the EMG data collection. The muscle tested was the right gluteus medius muscle on all subjects.

Before beginning the jump activities, a maximal voluntary contraction (MVC) was elicited from the gluteus medius muscle. Each subject performed three jumps taking off with both legs and landing on the right leg at a distance of 30% of their height. Participant held the landing for 3 seconds and then had a rest period before the next jump. The knee valgus angle, the footswitch and the EMG were all synchronized by the Noraxon MyoMuscle software program. Graphs were constructed showing the percent of MVC activity of gluteus medius and the amount of knee valgus that occurred during each jump and landing..

Results

In single jump landing all male and female participants exhibited knee valgus. Males and females demonstrated differences in %MVC of the gluteus medius and knee valgus. The gluteus medius demonstrated a greater average %MVC in males (37.15) compared to females (34.05). Males were found to have higher average knee valgus (7.5 degrees) compared to females (4.9 degrees). The males also demonstrated a larger range of knee valgus (5.7 degrees - 9.3 degrees) compared to females (4.2 degrees- 5.4 degrees) (Figure 3).

Overall there was no apparent relationship in the amount of knee valgus when compared to the %MVC of hip abductors between subjects. The increased hip abduction muscle activity did not result in decreased knee valgus in all subjects, however when comparing males to females the male subjects had a greater knee valgus to %MVC ratio (.1945) than females (.1545).

Discussion/Limitations

The results of this study shows some consistency with previous literature regarding hip abductor strength and knee valgus correlation between sexes.[1] That is, that hip abductor contraction does not correlate with dynamic valgus. Inconsistencies were also noted though a literature review. Multiple articles found that females tend to have a greater static q-angle and dynamic knee valgus when compared to males. Pantano et al.[2] found that pelvic width to femoral length ratios, rather than q-angle may be a better predictor of knee valgus during dynamic movement, after finding no significance in valgus between a high and low q-angle participants. Russell et al.[1] also determined that gluteus medius muscle activation did not differ between the sexes and thus does not appear to be responsible for the sex differences in knee valgus.

Limitations: The sample size was limited to 6 participants (4 females and 2 males). Future studies should include more participants to show a better representation with adequate power to allow statistical analysis. The study did not consider athletic ability, or BMI- both factors that may have impacted results. It would also be interesting to test subjects with previous knee injury followed by extensive physical therapy. Another limitation was the instruction given to participants. They were instructed on the distance length to jump and to land on a single leg, but not how to land, if the participants were instructed to focus on avoiding knee valgus and landing with minimal ground reaction force it may have made a difference. Many comparable studies documented static and dynamic q-angle to be included in analysis, in future studies we would also measure said values.

Experiments

Figure 1. Gluteus Medius Activity Following Jump and Landing

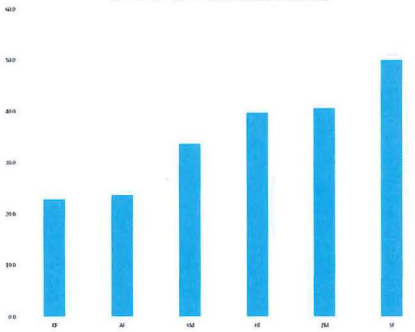


Figure 2. Knee Valgus Following Jump and Landing

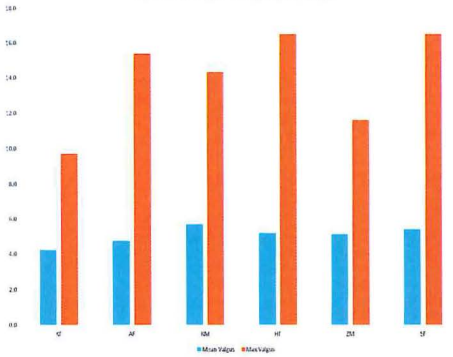
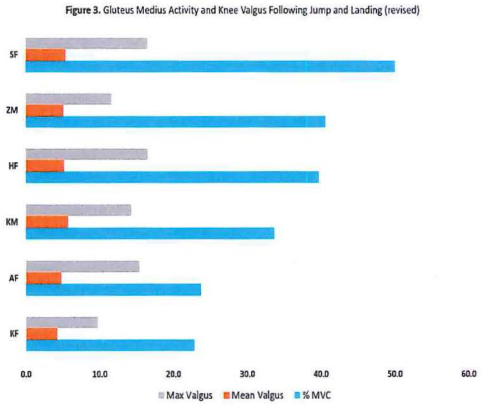


Figure 3. Gluteus Medius Activity and Knee Valgus Following Jump and Landing (revised)



References

1. Russell KA, Palmier RM, Zinder SM. Sex differences in valgus knee angle during a single-leg drop jump. *Journal of Athletic Training*. 2006; 41(2): 166-171.
2. Pantano KJ, White SC, Gilchrist LA, Leddy J. Differences i peak knee valgus angles between individuals with high and low Q-angles during a single limb squat. Clinical Biomechanics. (2005). 20: 966-972.

Conclusions

Research has shown that gluteus medius activation does not correlate to dynamic knee valgus and that females are more likely to demonstrate increase in dynamic knee valgus. Our findings did not have enough subjects to determine correlations between knee valgus and gluteus medius activation. Further research is needed to determine the impact of hip abductor strength to confirm or deny its correlation to dynamic knee valgus during jumping and landing activities. We recommend further exploration into other contributing factors to knee valgus in addition to gluteus medius activation.

UND School of Medicine & Health Sciences
The University of North Dakota