THE EFFECT OF AN ACL INJURY PREVENTION PROGRAM ON GLUTEUS MEDIUS STRENGTH BETWEEN GENDERS

A THESIS

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Jordan Blair

Research Advisor, Dr. Shelly DiCesaro

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CALIFORNIA, PA

THESIS APPROVAL

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We hereby approve the Thesis of

Jordan Blair
Candidate for the degree of Master of Science

Date	Faculty
6/14/11	Shelly DiCesare, PhD, ATC, CSCS Chairperson
5/23/2011	Thomas West, PhD, ATC
5/23/2011	Edwin Zuchelkowski, PhD

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INTRODUCTION

Anterior cruciate ligament (ACL) injuries have been estimated to account from 75,000 to 250,000 knee injuries per year.[1] While this does not make it an epidemic, the recovery time associated with this injury coupled with a higher incidence rate among females makes it one of the most ubiquitous injuries in the current athletic landscape. Due to the nefarious reputation of ACL injuries, there has been a copious amount of research conducted to advance the prevention of non-contact ACL (NCACL) injuries.

Non-contact ACL injuries account for approximately 70% of all ACL injuries that occur. The etiology of non-contact ACL injuries is still largely unknown, but a common mechanism of injury is a valgus collapse at the knee.[1] A valgus collapse of the knee is characterized by internal rotation of the femur, knee valgus, and ankle pronation. The risk factors for this injury have been identified as environmental, anatomical, hormonal, and biomechanical.[2-4] Anatomical, biomechanical, and hormonal factors are considered to be intrinsic because these are factors that are within the patient. Environmental factors are considered to be extrinsic because they consist of factors outside of the patient and, have potential to be controlled. These situations can range from weather conditions to playing surfaces to types of shoes worn by the athlete.

Analysis of studies on the incidence of ACL injuries place female athletes at a two to six times higher rate of NCACL injury when compared to males.[1,4-7] Due to this discrepancy, there has been an abundance of research performed to find the cause of this higher incidence rate. The results of available research point to five major gender influences differences that seem to influence ACL injuries in females, including anatomical differences between genders,[8] increased knee valgus angle,[9-14] internal rotation at the tibia,[15] hormonal influences,[16-18] and muscle activation patterns.[19,20] The gluteus medius has been identified as one of the key muscles in the prevention of patellofemoral injuries, and of the five major gender influences, the gluteus medius is a factor in knee valgus, internal rotation, and muscle activation.[21]

The identification of the higher incidence rates in female NCACL injuries created a push for the development of ACL injury prevention programs. While there have been multiple techniques used in the past, the most recent and successful ACL injury prevention programs utilize neuromuscular training.[22-25] These programs implement a combination of lower body strengthening and plyometrics that improve gluteus medius strength and muscle activation strategies while also improving the strength of surrounding musculature.

The purpose of this study is to examine the effect of a current ACL injury prevention program on gluteus medius strength in males and females. It is important to examine if this program provides the benefit of gluteus medius strengthening as well as attempt to identify if males and females share similar gluteus medius strength gains from the implementation of the program. Previous research has shown the need for hip abductor strengthening to prevent NCACL injuries.[9-14,22-25] Recognition of an ACL injury prevention program's effectiveness may lead to an increase in the use of the program at all levels of athletics, which in turn may lead to a decrease in the incidence of NCACL injuries suffered by males and females.

METHODS

Research Design

This research study utilized a quasi-experimental pre-test and post-test design using twelve male and twelve female subjects between the ages of 18 and 26 who were considered physically active. Subjects were considered physically active if they participated in physical activity at a moderate intensity for 30 minutes at least 3 times a week. The independent variables for the study were gender and ACL prevention program or control group assignment. The dependent variable was gluteus medius strength. Gluteus medius strength was measured using the Lafayette Manual Muscle Test System (MMTS). Results were compared between groups to observe the effect between the program and control group. Results also compared the program's effect between genders. Manual Muscle Testing System (MMTS) pre-test measurement provided a baseline from which effects of the program and control group were observed.

Subjects

The subjects consisted of 24 physically active male and female college student volunteers between the ages of 18 and 26. Participants were considered physically active if they participated in physical activity at a moderate intensity for at least 30 minutes three times a week. All subjects in the study signed an Informed Consent Form (Appendix C1), a Physical Activity Readiness – Questionnaire (Appendix C3), as well as a Demographic Sheet (Appendix C5) prior to participation in the study. Subjects were instructed to sign the Informed Consent Form only if they had read through it, understood the study, and had presented any questions to the researcher. Subjects were randomly placed in a study group so that there were no more than half the number in the control group that was in the experimental group. Each participant's identity remained confidential and was not included in the study. Participants who had been diagnosed with a lower extremity injury within the past six months, identified through the demographic sheet, were excluded from this study as those with recent injury may not be ready to participate in an injury prevention program.

Preliminary Research

Preliminary research for this study was conducted to familiarize the researcher with the MMTS and to determine the amount of time the muscle testing procedure as well as the exercise program took to complete. Two subjects, a male and a female, were tested for gluteus medius strength and then led through the ACL injury prevention program. The researcher looked for the subject's ability to understand directions on how to perform each exercise and the amount of time muscle testing took, as well as the amount of time needed for completion of the exercise program.

Instruments

The instruments used in this study were the Lafayette Manual Muscle Test System as well as assorted exercise equipment. The Lafayette Manual Muscle Test system (MMTS) is a handheld dynamometer that provides an objective way to measure the strength of a muscle. The reliability of dynamometers has been reported as high.[26] The following formula will be used to determine strength of the gluteus medius. Torque=(Force in Newtons) x (Distance in meters), Strength=(Torque/Body weight in kg)[27]

Procedure

The study began with the researcher holding an introductory meeting with the participants to discuss the requirements of the study as well as the procedures for the ACL injury prevention program. Subjects were informed of the anticipated time frame for the study as well as the amount of time the ACL injury prevention program would take. Subjects were then offered the Informed Consent Form once all questions were answered and the researcher had covered all aspects of the study pertinent to the subjects. Subjects were then given a sheet to sign up for a time in which baseline testing was performed. Testing took no more than twenty minutes and was done prior to the first day of the experimental groups exercise session.

On the first day of the experimental group's exercise session, each exercise was demonstrated so that the subjects were aware of proper technique and form. Packets with each exercise's description and pictures were provided to the participants to ensure an information source was present if a subject was unsure of technique or form.

After the first exercise session, specific times for each subsequent, were assigned. Either the researcher or an approved student from California University of Pennsylvania's Athletic Training Education Program, who was trained in the proper techniques of the exercises, was present at each session. Attendance logs were also maintained during the study to ensure compliance within the experimental group. Data from subjects missing more than two exercise sessions or two sessions in a row were not included in the study. Post-tests occurred no later than one week following each subject's final exercise session.

Trunk Neuromuscular Training

The trunk neuromuscular training (TNT) program was developed by Myer et al[23] to focus on core musculature as well as the hip stabilizers to decrease the risk of ACL injury in females. The training sessions were conducted two days per week for six weeks as per modified recommendations of the authors. Each training session lasted approximately 25 minutes. The program consists of five progression phases. Progressions were implemented once a participant demonstrated mastery of each exercise in a given phase. Each phase consisted of 13 exercises that gradually build in intensity. Each phase followed the subsequent exercise progression: lateral jump and hold, step-hold, BOSU swimmers, DOSU double knee-hold, single leg lateral Airex hop-hold, single tuck jump-soft landing, front lunges, lunge jumps, BOSU double leg pelvic bridges, single leg 90 degree hop-hold, BOSU lateral crunch, box double crunch, and Swiss ball back hyperextensions. Since a warm up was not specified in the program, a dynamic warm up consisting of a slow jog for 30 seconds, toe walks for 10 yards, straight leg kicks for 10 yards, leg swings for 30 seconds, high knees for 10 yards, and butt-kicks for 10 yards were implemented to reduce the risk of injury.

Hypotheses

The following hypotheses were based on previous research and the researcher's intuition based on a review of the literature.

1. The subjects placed in the Trunk Neuromuscular Training program will enhance gluteus medius strength significantly more than the subjects placed in the control group.
2. Females placed in the Trunk neuromuscular Training Program will significantly increase their gluteus medius strength when compared to males.

Data Analysis

All data was analyzed with SPSS version 19.0 with significance set at an alpha level of 0.05. The research hypotheses will be analyzed using an independent T test.

RESULTS

Demographic Data

A total of twenty-four subjects (n=24, 12 male, 12 female) participated in this research study. Two participants were unable to complete the study requirements, so data for twenty-two (n=22, 11 males, 11 females) subjects was analyzed for significance. The experimental group consisted of twelve subjects (n=12, 7 male and 5 female), and the control group consisted of ten subjects (n=10, 4 male and 6 female). All subjects were volunteers that were physically active, as defined by the American College of Sports Medicine as exercising at least three times a week for thirty minutes per session at a moderate to intense level, and had not suffered a lower body injury within six months prior to the beginning of the study. Demographic data, which is demonstrated in Table 1, was collected by the researcher at the beginning of the study.

Table 1. Demographic Data of all Subjects

		Right Femur Length (m)	Left Femur length (m)	Weight (kg)	Age (yrs)
Male	Mean	0.438	0.437	80.08	21.73
	N	11	11	11	11
	Std. Deviation	0.0318	0.0313	16.266	1.902
Female	Mean	0.412	0.412	67.06	20.82
	N	11	11	11	11
	Std. Deviation	0.0158	0.0152	12.72	1.834
Total	Mean	0.425	0.425	73.57	21.27
	N	22	22	22	22
	Std. Deviation	0.0279	0.0273	15.729	1.882

Hypothesis Testing

Statistical analysis was performed on data from all twenty-two subjects that completed the study with significance set at an alpha level of ≤ 0.05. All final means were measure in Newtons.

Hypothesis 1: The subjects placed in the Trunk Neuromuscular Training program will enhance gluteus medius strength (GMS) significantly more than the subjects placed in the control group. Hypothesis 1 was tested utilizing an independent t-test. Average GMS comparing the experimental group to the control group found that there was a significant difference between the means of the two groups (t = 2.697, p = 0.016). The mean GMS difference of the experimental group was significantly higher (m = 0.0618, sd = 0.02257) than the mean of the control group (m = -0.0057, sd = 0.01077). This is displayed in Table 2 below.

Table 2: GMS difference between the Experimental and Control Groups

	N	Mean (Nm/kg)	Std. Dev. (Nm/kg)	Sig. (2-tailed)
Training Group	12	0.0618	0.02257	p = 0.016
Control	10	-0.0557	0.01077	

Hypothesis 2: Females placed in the Trunk Neuromuscular Training Program will significantly increase their gluteus medius strength when compared to males. The independent-samples t-test was calculated comparing the mean scores of males in the experimental group and the mean scores of females in the experimental group. No significant difference was found (t = -0.665, p = 0.527). There was no significant difference between the mean GMS difference of males (m = 0.0489, sd = 0.06312) to the mean GMS difference of females (m = 0.0797, sd = 0.10072) in the experimental group as can be seen in Table 3.

Table 3: GMS difference between Males and Females in the Training Group

Gender in Training Group	N	Mean (Nm/kg)	Std. Dev. (Nm/kg)	Sig. (2-tailed)
Males	7	0.0489	0.06312	p = 0.527
Females	5	0.0797	0.10072	

Additional Findings

Dominant leg gluteus medius strength between the experimental and control groups, non-dominant leg gluteus medius strength between the experimental and control groups, and the averages of the dominant leg and non-dominant leg gluteus medius strength (GMS) between groups were all analyzed for additional findings.

Dominant leg GMS comparing the experimental group to the control group found that there was not a significant difference between the means of the two groups ($t = 1.786$, $p = 0.098$). The mean GMS difference of the experimental group ($m = 0.0473$, $sd = 0.09376$) was not significantly different from the mean GMS difference of the control group ($m = -0.0029$, $sd = 0.02454$) as can be seen in Table 4.

Table 4: Dominant leg GMS change between the Training and Control Groups

	N	Mean (Nm/kg)	Std. Dev. (Nm/kg)	Sig. (2-tailed)
Training Group	12	0.0473	0.09376	p = 0.098
Control	10	-0.0029	0.02454	

Non-dominant leg GMS comparing the experimental group to the control group found that there was a significant difference between the means of the two groups (t = 2.649, p = 0.015). The mean GMS differences of the experimental group (m = 0.0762, sd = 0.08523) was significantly different from the mean of the control group (m = -0.0084, sd = 0.05909) as can be seen in Table 5.

Table 5: Non-Dominant leg GMS change between the Training and Control Groups

	N	Mean (Nm/kg)	Std. Dev. (Nm/kg)	Sig. (2-tailed)
Training Group	12	0.0762	0.08523	p = 0.015
Control	10	-0.0084	0.05909	

A paired-samples t-test was performed to determine if there was a significant difference between gluteus medius strength of the dominant and non-dominant legs in the experimental group after six weeks of training. There was no significant difference (t = -1.143, p = 0.277) in the mean GMS of the dominant leg compared to non-dominant leg in the experimental group. The mean of the dominant leg GMS differences was 0.0473 (sd = 0.09376), and the mean of the non-dominant leg GMS difference was 0.0762 (sd = 0.08523) as can be seen in Table 6.

Table 6: GMS difference between Dominant and Non-Dominant Legs in the Training Group

	N	Mean (Nm/kg)	Std. Dev. (Nm/kg)	Sig. (2-tailed)
Dominant	12	0.0473	0.09376	p = 0.0277
Non-Dominant	12	0.0762	0.08523	

A one-way ANOVA was performed comparing the average GMS of the experimental group and the amount of days missed (0,1,or 2). No significant difference was found (F (2,9) = 2.507, p = 0.136). The mean GMS difference for days missed were 0 = 0.0968 ± 0.02496, 1 = 0.1032 ± 0.12078, and 2 = 0.0089 ± 0.02465 as can be seen in Table 7.

Table 7: Average GMS Difference Compared to Days Missed

Days Missed	N	Mean (Nm/kg)	Std. Dev. (Nm/kg)	Sig. (2-tailed)
0	4	0.0968	0.02496	p = 0.136
1	3	0.1032	0.12078	
2	5	0.0089	0.05511	
Total	12	0.07819	0.07819	

DISCUSSION

The following is divided into three subsections: Discussion of Results, Conclusion, and Recommendations.

Discussion of Results

The high rate of non-contact anterior cruciate ligament injuries, specifically in females, has caused a surge of research on preventative measures as well as NCACL injury prevention programs.[1,22-25] Injury epidemiology research suggests that the hip and surrounding musculature may play an important role in the poor biomechanics associated with increased injury risk.[1] The gluteal muscles are the primary hip stabilizers, with the gluteus medius being the primary hip abductors and lateral stabilizers. The role of the gluteus medius and hip stabilizers in NCACL injuries has lead to the inclusion of exercises in prevention programs to improve strength and balance of these muscles.[9-14,22-25] The higher NCACL injury incidence rate in females coupled with the decrease in gluteus medius strength in females compared to males supports the theory of the gluteus medius as a major component in the prevention of NCACL injuries.[4-7,9-14] An exhaustive search of the literature did not yield any published studies that have tested an ACL injury prevention program's effect on gluteus medius strength. This study was performed to provide data exploring potential strength changes in hip musculature strength with the use of an ACL injury prevention program.

The lack of research studying the change in hip abductor strength following the implementation of an ACL injury prevention program inspired this study incorporating a six week implementation of the Trunk Neuromuscular Training Program (TNT) and comparing the results of hip abductor strength differences to a control group. The paucity of research in this area leads to little comparable data for the first hypothesis that those in the training group would significantly increase their gluteus medius strength compared to those in the control group after the TNT Program implementation. Two studies, one by Chimera et al and the other by Hewett et al, investigated hip abductor musculature following a training protocol, however these studies did not include strength measures.[28,29] Chimera et al noted a significant change in adductor to abductor muscle co-activation during a vertical jump after the implementation of a six week training protocol.[28]

Similarly, Hewett et al found a decrease in varus and valgus movements following training and suggested the results showed an increase in dynamic support of the hip joint.[29] Each study utilized a plyometric based training protocol. Plyometric training is the basis for the Trunk Neuromuscular Training Program used in this study. With the observations of hip musculature change in these studies we theorize that they support our findings of a significant change, a 4.4% increase in average gluteus medius strength, can be observed after the implementation of the Trunk Neuromuscular Training Program after six weeks.

As previously stated, females suffer from a two to six times higher incidence rate of NCACL injuries compared to their male contemporaries.[1,4-7] Several studies have also shown that females differ significantly in hip abductor strength and muscle activation patterns compared to males of similar age.[9-14] A large emphasis has been placed on female NCACL injury research in previous years, which explains why many programs that are currently available employ language suggesting they are for female use.[1,22-25] The Trunk Neuromuscular Training Program (TNT), designed by Myer et al, is a prevention program that utilizes gender-specific language.[24] This suggests, but does not confirm, that it is intended by the authors for female use. The differences experienced by males and females during high risk situations that may lead to a NCACL injury are well documented. The lack of research testing ACL injury prevention programs extends into the realm of gender differences experienced during the execution of a prevention protocol. To investigate our second hypothesis, that females in the training group will increase their gluteus medius strength significantly more compared to males, we compared the gluteus medius strength differences of the males in the experimental group to the females in the experimental group. The lack of a significant difference suggests that the TNT program significantly and equally strengthens the gluteus medius in both males and females. These results show an impartial change in GMS despite noted anatomical, biomechanical, and hormonal differences between males and females in relation to anterior cruciate ligament injuries.[2-4] These findings also suggest that, despite females on average having a decrease in GMS compared to males along with altered muscle activation patterns according to Cowley et al, they do not have strength increases that differentiate for the strength gains seen in males.[9-14]

Further analysis of data used for the first hypothesis was performed during additional findings. These results showed there was not a significant difference in dominant leg GMS change in the experimental group, only 3.3% increase, when compared to the control group, -0.4%. This is in contrast to the significant GMS difference experienced by the non-dominant leg in the training group, which was a 5.4% increase. A comprehensive search of all available research found only one study that examined hip-abductor strength and leg dominance. According to Jacobs et al, the gluteus medius peak-torque is significantly higher in the dominant leg compared to the non-dominant leg.[30] This may explain the lack of significant improvement seen in the dominant leg gluteus medius when compared to the non-dominant. The majority of GMS was gained on the non-dominant side which is, when compared to the results of Jacobs et al, the weaker side.[30] This could indicate that, during this study, the progression of each phase in the TNT program was dependent on the development of the non-dominant leg gluteus medius strength. While these findings provide an intriguing theory, they remain in contrast to the lack of significance between a comparison of GMS change of the experimental group's dominant and non-dominant legs.

A review of available literature indicates that many studies focus on the dominant leg when collecting ACL research.[10,12,20,21] Using our results showing the non-dominant leg gluteus medius receiving the majority of the benefit, we can theorize that solely testing the dominant leg could potentially skew the outcome of a research study. Future research that would be of interest would use parameters of a previous study that only tested the dominant leg ACL and assess both legs. The incorporation of single leg as well as double leg exercises emphasizing equal effort bilaterally are an important part of the Trunk Neuromuscular Training program and has been cited by Myer et al as an effective way of treating leg dominance.[23,24] It is for this reason that during the implementation of the TNT program, the clinician needs to aware and attentive to proper form so that the dominant leg is not overloaded, potentially causing a neuromuscular pattern that could lead to injury.

Statistics were also run to determine if the number of training sessions missed altered the final dominant leg, non-dominant leg, and average GMS scores of the subjects. No published data was found to compare the number of sessions missed in a protocol compared to reliability or validity of the final results. In an effective training protocol, it is important to determine how many sessions can be missed before strength gains begin to decrease as compliance is usually not 100%. For the purposes of this study, the maximum number of sessions that the subjects were able to miss was two. Of the twelve subjects in the experimental group four did not miss, three missed one day, and five missed two days. The results of the analysis showed that there was not a significant difference between the number of days missed and GMS in the experimental group. Despite the lack of significance, there was a definite trend between those who missed zero or one day of training compared to those who missed two days. Those who missed two days of training had a GMS score of .0943 Newtons, or about .924 kg of force, less than those who missed either one or zero days of training. This may suggest that future research should analyze similar variables and exclude participants that miss multiple sessions.

Conclusions

This study demonstrated that after a six week ACL injury prevention program incorporating specific muscles for the core and hip, there is a significant increase in the average gluteus medius strength scores. There was significant difference in the average gluteus medius strength scores between males and females in the experimental group after the six weeks of training. Additionally there was a lack of significance in the difference of strength gains between the dominant leg gluteus medius strength scores and the non-dominant leg gluteus medius strength scores. Finally, there was a lack of significance in the post-test average, dominant and non-dominant gluteus medius strength scores when compared to the minimum and maximum amount of days missed, though there was a definite drop-off trend noticed.

Our findings of higher strength gains in the non-dominant leg as opposed to the dominant leg suggest that weaker subjects may see a maximal benefit from the use of this program seeing as the weaker side, non-dominant, saw a larger increase in GMS. The strength gains seen in males and females imply that this program is significantly effective for both genders as well as a variety of levels of gluteus medius strength. While gluteus medius strength concerns only account for a small portion of the risk factors associated with non-contact ACL injuries, the widespread implementation of this program could potentially decrease the number of injuries seen in relation to this injury.

Recommendations

There is a lack of research investigating muscle strength gains from ACL injury prevention programs.[1] It is extremely important to identify the most successful program and the time frame in which the use of these programs can provide the maximum amount of benefits between males and females. Our findings from this study, while not staggering, show the benefits gained from the implementation of a particular ACL injury prevention program over a six week, 12 session period. Larger numbers studied may confirm the findings of our experiment. The next step would be to identify the minimal amount of time needed to see meaningful benefits from the use of this program. Additionally, it would be interesting to study at what point the benefits begin to plateau and the introduction of a change in the program is needed. Lastly, testing of all muscles used in the prevention of non-contact ACL injuries, such as the quadriceps, hamstrings, and abdominals, would further add legitimacy to the prevention programs.

There was no significant difference noted between the GMS scores of the males and females. Muscle activation patterns remain a significant theory in the cause of a higher incidence rate of non-contact ACL injuries in females. For this reason it would behoove future researchers to measure not only strength gains, but EMG muscle firing patterns as well.

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APPENDICES

APPENDIX A

Review of Literature

REVIEW OF LITERATURE

The purpose of this literature review is to discuss the gluteus medius and its relationship to non-contact anterior cruciate ligament (NCACL) injuries and ACL injury prevention programs. Anterior cruciate ligament injuries are one of the most prevalent injuries in athletics. It has been suggested that 75,000 to 250,000 ACL tears occur in the United States each year.[1] Unfortunately, for female athletes, they suffer a four to six time higher incidence rate for non-contact ACL injuries compared to male athletes of a similar age.[1] While current research has brought us closer to understanding this discrepancy, there remain uncertainties to this complicated issue. Several factors for the increase in injury among females have been suggested. These factors include anatomical, hormonal, biomechanical, and neuromuscular differences between genders.[1,2] Regardless of gender, it is important to implement injury prevention programs that focus on reducing the occurrence of anterior cruciate ligament injuries.

The gluteus medius plays a key role in the prevention of patellofemoral injuries.[3] The strengthening of this muscle should be included in any preventative ACL injury program. Not all prevention programs include the same components, so it is extremely important to understand the components and the effectiveness of these programs. This literature review will outline the importance of the gluteus medius in ACL injury prevention by discussing what a noncontact ACL injury is, the anatomy involved including the functional anatomy, the role of the gluteus medius, and specific gender differences as well as mechanical alterations and current ACL prevention programs and their components.

Noncontact ACL Injuries

For an ACL injury to be considered noncontact, there needs to be an absence of outside contact with the knee during the time of injury. While the exact etiology of noncontact anterior cruciate ligament injuries remains unknown,[1] recent research has aided in our understanding of risk factors. A study by Griffin et al defined environment, anatomy, hormonal, and biomechanics as the four typical risk factors for ACL injuries.[4] These factors will be discussed in later sections in more detail. Situations that can create a force necessary for a noncontact ACL injury include, but are not limited to, landing from a jump, sudden changes in direction, and deceleration.[1] Most noncontact anterior cruciate ligament injuries tend to happen in the closed kinetic chain. When the body is in direct contact with the physical environment, it can create a model situation for injury. For example, during a drop jump landing, an increase in knee valgus force coupled with internal rotation of the femur creates a common mechanism of injury.[1] The increase in internal rotation of the femur can be due to a weakness in hip external rotators, including the gluteus medius.

Muscular weakness is also a major contributor to noncontact ACL injury. A lack of co-contraction of the hamstrings during quadriceps contraction can create the shear forces necessary to cause an anterior cruciate ligament injury when the knee is at or near full extension. Understanding of the definition of noncontact ACL injuries is important when trying to determine the incidence of these injuries in sports.

Incidence

The incidence of noncontact anterior cruciate ligament injuries has been estimated at approximately 70% of all ACL injuries.[1,4] Prevalence and incidence are two separate concepts that are, unfortunately, commonly misused and misunderstood. Incidence is the rate in which something occurs within a population. Incidence as it pertains to ACL injury research is done in a prospective manner studying the number of injuries sustained in a group of subjects during a predetermined amount of time. It is difficult, if not impossible, to determine the number of anterior cruciate ligament injuries within the general population. Even with the National Ambulatory Care Surveys, all cruciate ligament injuries are reported under the same ICD code, creating mixed numbers. Even if it were possible to differentiate between the injuries in this situation, the survey covers total visits for ACL injuries, which could be an indeterminable number per patient.[1] With these limitations aside, incidence rates have been determined in smaller populations. There have been many studies that focus on anterior cruciate ligament injury within specific athletic populations.

A study done by Uhorcak et. al. analyzed 859 West Point Cadets over four years to better understand the incidence and risk factors that are present in an athletic population.[5] While military men and woman are not considered athletes, their training and conditioning are certainly athletic in nature, therefore allowing for comparisons. All 859 cadets were assessed by physical examination, strength assessment, and exposure data. Of the 859 cadets there were 29 anterior cruciate ligament injuries over the four year study. Twenty four of these were considered noncontact. This is an incidence rate of approximately 3.4% in the general population and an 82.7% noncontact injury rate, which is significantly higher than the previously noted 70%. The benefit of this study is that it incorporates males and females as well as clearly defining noncontact ACL injuries. The differentiation of male and female subjects is important because it shows the large discrepancy between the genders. The incidence rate for females was found to be 6.6% while it was only 2.1% in males. The authors cite specific anatomical and physiological reasons that are to be discussed later in this review.

The National Collegiate Athletic Association Injury Surveillance System (ISS) was developed in 1982 to provide the most up to date and reliable data on injury trends. This has been an invaluable tool for researchers trying to identify injury discrepancies between sports, gender, and collegiate division. A study done by Agel et al[6] used the ISS to follow noncontact ACL injuries between males and females participating in basketball and soccer. This study was built upon previous results,[7,8] giving an extensive look into ACL injury patterns. When the researchers compared noncontact ACL injuries between genders, the results were mostly similar to previous studies. Male basketball players suffered a 70.1% rate of noncontact ACL injuries compared to contact while female basketball players suffered a 75.7% rate. Males suffered 37 contact and 78 noncontact injuries, while females suffered 100 contact and 305 noncontact ACL injuries. Though this was not considered a significant difference from previous results, the results from soccer showed a note worthy change. Male soccer players suffered a 49.6% rate of noncontact anterior cruciate ligament injuries while the rate for females was 58.3%. The 49.6% rate for males was considered a significant decrease, which causes one to wonder as to the reason for the change. Further results from the study showed that regardless of the sport, females had a much higher incidence rate of anterior cruciate ligament injury. While this information is extremely important in the identification of the injury discrepancy, it does not mean that ACL injuries in males should be ignored, especially since there are more males experiencing NCACL injuries per year than females.

Anatomy

It is extremely important to understand the anatomy involved in anterior cruciate ligament injuries. In order to understand the possible etiologies of noncontact ACL injuries, one must understand how stability is maintained within the knee joint. There are two joints within the complex of the knee, the patellofemoral and tibiofemoral. The patellofemoral joint is the articulation of the patella and the femur, while the tibiofemoral joint is articulation of the femur on the tibial plateau.

Additionally, there are two types of stabilizers in the knee; passive and dynamic. Passive stabilization is provided by the joint capsule, the menisci, the anterior cruciate ligament, the posterior cruciate ligament (PCL), the lateral collateral ligament (LCL) and the medial collateral ligament (MCL). Dynamic stabilization is provided by the muscles that cross the knee joint, which are the quadriceps muscles and the hamstring group.[9]

Reference to how important the ACL is can be heard nearly every time a star athlete sustains a knee injury, but often times the general public lacks the understanding of why it is so important. The main functions of each of the cruciate ligaments (ACL and PCL) are exact opposites.

The ACL attempts to impede anterior tibial translation on the femur and the PCL attempts to stop a posterior shear force of the tibia on the femur. While this may seem backwards, the ligaments receive their names from their origins. The ACL originates at the anterior intercondylar area of the tibial plateau and inserts to the posteriomedial part of the lateral femoral plateau. Conversely, the PCL originates in the posterior aspect of the intercondylar notch and inserts at the anterior inferior lateral aspect of the medial femoral plateau.[9]

Anatomy Involved in ACL Injury

According to Griffin et al, there has not yet been a reliable measure of any single anatomical variable that increases the risk of anterior cruciate ligament injury.[10] This does not, however, discount the fact that several anatomical factors have been suggested as risk factors for ACL injury. These factors include femoral intercondylar notch width, pelvic angle, quadriceps angle, and subtalar pronation.[1]

Suggestions of intercondylar notch width's relationship to ACL injury are not a recent development, and yet there is little empirical data that can give a definitive answer. Also, recent conflicting MRI studies have increased the uncertainty.[11,12] The exact correlation between a decreased intercondylar notch width and ACL injury has not been specified. However, further findings in the study done by Uhorchak et al.[5] suggested that the increase of ACL injury in those with a smaller intercondylar notch width could be due to an abnormal loading of the ACL as well as a smaller ACL, which would lead to a decrease in the ultimate failure point of the ligament.

Unlike intercondylar notch width, there is little controversy surrounding the hypothesis of pelvic angle's effects on ACL injury. It has been suggested that an increase in anterior pelvic tilt can create a medial collapse of the lower extremity, causing internal rotation of the femur leading to genu valgus at the knee. It has also been noted that anterior pelvic tilt can create other structural abnormalities such as genu recurvatum and subtalar pronation.[13] Dynamic stability is also compromised due to a stretch weakness of the hamstrings.

The quadriceps angle, also known as the "Q" angle, is a measurement formed by the alignment of the center of the patella to the anterior superior iliac spine and the center of patella to the tibial tuberosity. It is well documented that a Q angle greater than 20 degrees can lead to a patellofemoral pathology.[14] An increased quadriceps angle can also lead to an increase in knee valgus and torsion within the knee.[1]

Subtalar pronation is often overlooked in patients with an ACL injury. Pes planus is typically the cause of subtalar pronation. The excessive pronation that is occurring at the joint creates an internal rotation of the femur, leading to internal rotation at the knee.[15] This internal rotation at the knee places a stress on the ACL and may contribute to a higher risk for injury. This is a condition that can easily be exaggerated by other biomechanical issues, such as an internal rotation of the femur, causing a larger medial collapse.

It is important to note that anterior cruciate ligament injuries are typically a result of several factors. Though some of the mentioned studies focus on a single reason, it does not indicate that other factors were not present. There are other factors that have been suggested, but have little to no supporting evidence. These factors include femur to tibia length, anteversion of the hip, tibiofemoral angle and genu recurvatum.[1]

Role of Gluteus Medius

The primary function of the gluteus medius is to abduct the hip and internally rotate the thigh. It takes its origin from the iliac crest and inserts on the greater trochanter.[16,17] The gluteus medius is also a pelvic stabilizer, which is extremely important in preventing a medial collapse and maintaining proper kinematics of the lower extremity.[18] A medial collapse is characterized by an internal rotation of the femur, knee valgus, and subtalar pronation. In a study performed by Brindle et al.[3] gluteus medius weakness was found to be related to anterior knee pain in subjects performing ascent and descent of stairs. With this in mind, it only seems right to implement a comprehensive strength training prevention program that effectively targets the gluteus medius and surrounding musculature.

Differences between Gender

Gender differences have been suggested in several studies as a reason for the greater incidence of NCACL injuries in females.[19-32] This leads to the discussion of several areas where key differences have been studied; anatomical,[19] knee valgus angle,[20-25] femoral internal rotation,[26] hormonal differences,[27-30] and muscle activation patterns.[31,32]

Recent research has identified four typical anatomical differences between males and females that may lead to NCACL injuries. Medina et al collected measurements from 118 males and females ranging from active adults to elite athletes.[19] Their findings showed that women demonstrate larger quardriceps angles, more genu recurvatum, greater anterior pelvic tilt and larger femoral anteversion when compared to males. The researchers suggest that the structural differences can lead to biomechanical alterations.[19]

Single leg landings are a functional test that multiple studies use to test knee valgus angles. Many sports require athletes to jump, and this sudden deceleration is a typical mechanism for anterior cruciate ligament rupture.[1] Studies done by Russell et al.,[20] Garrison et al.,[21] Hughes et al.,[22] and Jacobs et al.[23] implemented the use of a drop jump to measure valgus angles in the knee between the genders. Each study found that females exhibited a greater valgus angle during their landings when compared to males. Two of the studies also tested for differences between the genders' hip abduction upon landing.[20,22] One study did not find a difference in muscle activation strategy between males and females,[20] while the other's findings suggested that females demonstrate a lower activation rate of hip abduction.[22]

Differences are not only seen between genders in the case of knee valgus, but also between females participating in different sports. In a study done by Cowley et al[24] between female basketball and soccer players it was found that females typically demonstrated greater knee valgus angles during sport specific tasks, such as jumping and landing in basketball and cutting in soccer. The results of this study also discovered greater knee valgus moments during cutting tasks compared to landing tasks among females. This supports the incorporation of sport specific movements into NCACL injury prevention programs to strengthen the appropriate musculature and possibly decrease knee valgus angles.

Gender differences have been noted as early as twelve years of age by Ford et al[25]. In their study, in which 54 male and 72 female athletes of adolescent age performing a cutting maneuver, it was found that the females suffered from not only greater knee valgus angles during the landing and stance phases when compared to males, but also from a higher maximum ankle eversion during the landing phase and decreased inversion during the stance phase. This suggests that ACL injuries may be influenced by ankle kinematics.

Many studies tend to focus on knee valgus measurements instead of potential causes for an increase in hip adduction. In a study by Hewett et al[26] hip adduction angles were measured in male and female athletes performing a single leg, bidirectional deceleration maneuver. Results of this study showed that females suffer from a larger angle of hip adduction during all phases of the maneuver. An increase in hip adduction motion can predispose an athlete to a functional medial collapse, creating a perfect environment for NCACL injury.[26]

Another area of difference between genders involves changes at the molecular and hormonal levels. A difference in collagen gene expressions between genders is a relatively recent area of study in consideration of anterior cruciate ligament injuries.[27] There are primarily two types of collagen in the ACL; type I collagen and type III collagen. Type I collagen makes up about 90% of the ACL while type III makes up approximately 10%.[25] Liu et al harvested the ACLs of 17 male and 17 female athletes who required ACL reconstruction and tested them using reverse transcript-polymerase chain reaction to determine if a difference in fibroblast collagen gene expression existed.

Their findings showed a significantly different lower relative expression of collagen I in the females. The question remains as to why this is the case, but the researchers do theorize that hormonal differences may be the cause.[27]

A 2006 study by Eiling et al[28] focused on the effects of the menstrual cycle on musculotendinous stiffness as well as knee laxity. The tests were performed during each phase of the menstrual cycle using a knee arthrometer. The measurements that were produced showed, on average, a 4.2% decrease in musculotendinous stiffness during the ovulatory phase.[27] The decrease in musculotendinous stiffness can lead to a reliance on noncontractile tissue to support a joint. In this case that would mean more forces acting on the ACL in female athletes than male athletes. This evidence was supported in 2007 by a survey study that viewed previous ACL injuries of females and the stage of their menstrual cycle at the time of injury. 72% of the subjects who had suffered a noncontact ACL injury did so during the ovulatory phase.[28]

Suggestions of hormonal relations to non contact ACL injuries in females are not, however, fully supported. Both studies previously mentioned suffer from a limited sample size. While they both present an interesting look into the possibilities of the subject, neither has been validated and are, in fact, currently being challenged as incorrect through a research study underway at Pennsylvania State University using similar methods.[29]

A difference in muscle activation patterns between genders has been suggested as a cause for the higher incidence of NCACL injuries in females.[24,30,31] A delayed or limited activation of certain muscles during the landing phase of a jump, like the gluteus medius, may lead to NCACL injuries. Similarly, if there is a delay or an over compensation in muscle activation patterns during cutting tasks there is a possibility for injury.

A study by Hart et al[30] examined eight male and eight female soccer players performing a single leg landing. The researchers collected surface electromyography data from the gluteus medius, vastus lateralis, lateral hamstring, and medial gastrocnemius during the jumps of each participant. Their results showed that the males had significantly higher gluteus medius activity during the landing when compared to the females.

Hanson et al[32] recorded surface electromyographic activity for the rectus femoris, vastus lateralis, medial and lateral hamstrings, gluteus medius and gluteus maximus during a running-approach side-step cut and a box-jump side-step cut in twenty males and twenty females. The participants used in the study were NCAA division I athletes. Results from this study demonstrated that females suffer from larger quadriceps activation as well as a larger quadriceps to hamstring coactivation ratio. The greater activation of the quadriceps without the hamstrings counter balancing them creates an anterior shear force within the knee, placing stress directly on the ACL. These findings are also significant in that they confirm that the quadriceps to hamstrings coactivation ratio exists in advanced athletes as well as recreational athletes.[31]

Mechanical Alterations

Structural alterations are not solely responsible for the occurrence of ACL injuries. Dynamic factors such as fatigue can create a harmful situation for the athlete. These mechanical alterations can lead to a loss of dynamic stability, leaving the anterior cruciate ligament prone to injury. The relationship of muscle fatigue and ACL injury has been previously suggested.[32,33] Chappell et al.[32] found that knee kinetics are significantly affected when muscle fatigue is introduced to three jump stop tasks. The results showed an increase in anterior tibial translation, which can place an undesirable stress on the ACL, possibly causing injury. In a related study by Melnyk and Gollhofer,[33] fatigue in the hamstrings was found to cause an increase in anterior tibial translation as well. The decrease in latency response of the hamstrings significantly affected the muscles ability to stabilize the knee joint. Fatigue of hip abductors also presents a problem to the athlete. Carcia et al[34] outlined a study that created bilateral fatigue in the hip abductors of their participants and then observed changes in their landing characteristics during a drop jump. The fatigue of hip abductors was found to significantly increase knee valgus, possibly leading to injury in the ACL.

Prevention Programs

After reading through the research on ACL injuries, there is a quick realization that preventative measures need to be taken to combat these injuries. Different techniques have been used and implemented to decrease the incidences of ACL injury. Recently there have been significant gains in NCACL injury prevention programs focusing on neuromuscular training programs that have been shown to reduce the incidence of NCACL injuries.[36-37]

Components

Neuromuscular training programs focus on a decreased risk of injury. While not all programs are the same, typically the more common components of successful programs include technique training and plyometric training. A relatively new suggestion involving the implementation of core exercises to increase stability and proprioception is theorized to have an effect on lower extremity kinematics.[36-38]

Previous Results

Seeing the need for prevention programs, many studies have tested the effects of certain exercises on musculature as well as prevention programs as a whole. It is important to identify which muscles need to be strengthened. Many studies identify gluteus medius weakness as a predisposition to injury.[3-5,16-18,22,25,30,34] Though the gluteus medius is an important muscle, it is certainly not the only muscle of interest concerning ACL injury prevention. The sheer amount of literature on the subject proves that there is no single answer to this complicated problem. In order to understand where ACL prevention programs are going, it is necessary to understand the related literature.

McCurdy et al tested the electromyography activity in specific muscle groups of the hip and knee during a single leg squat as well as a two legged squat.[40] Eleven female athletes were tested during three repetitions at 85% of each athlete’s one repetition maximum. The results from the study show that single leg squats produce a higher mean peak activity in the gluteus medius and hamstrings while a two legged squat’s activity levels are higher in the quadriceps. These results suggest that when training to target the gluteus medius muscle, single leg squats are more effective than two legged squats.[40] The study’s focus on females prevents a complete translation in similarity to males, but it does allow for some speculation.

In a study done by Boudreau et al, muscle activation patterns of the rectus femoris, gluteus maximus, and gluteus medius were measured in 44 healthy individuals while performing three trials of lunges, single leg squats, and step up and overs. The results found that lunges were the best choice of the three exercises for gluteus medius activation.[41] Although the study was performed using an equal number of men and women, the study mentions no differences between the genders in the levels of muscle activation for each exercise. These results clearly show that lunges can be potentially one of the best exercises when attempting to strengthen hip abductors.

Further studies outline marked improvements in neuromuscular training's effects on noncontact ACL injury prevention.[42-45] It is interesting though, that there has been an abundance of research on the different effects of NCACL injury prevention training, but there has not yet been a clear decrease in the occurrence of this injury.[6,46]

Use of Prevention Programs

Before a prevention program is fully implemented, Hewett et al suggests that the participant is evaluated through a series of jump tasks to identify ligament dominance, quadriceps dominance, and leg dominance.[47] These are three neuromuscular risk factors that are easily identifiable and can be corrected during the execution of the program. With ligament dominance there is an imbalance of neuromuscular control, leading to a reliance on the ligament for the majority of support.[48] This is typically characterized by a lack of control of knee valgus during jumping and cutting and should be identified by watching the subject perform a maximal vertical jump.[46] Quadriceps dominance is presented as an unproportionate increase in the quadriceps to hamstring ratio, with the quadriceps muscle overpowering the hamstrings.[49] This creates a shearing force within the knee, placing stress on the ACL. Dominance of the quadriceps can be determined easily through the use of leg curl and leg extension machines. If the subject has a hamstring to quadriceps ratio of less than 55% they may be considered to suffer from quadriceps dominance.[47] Leg dominance is defined as a lack of strength, coordination and balance before the lower limbs by Myer et al.[47] There are several different ways to test for leg dominance. The first method is to measure strength and determine if one limb can exceed the other by 20% or more. The second method consists of a balance test to observe postural sway. The final measurement of leg dominance is the use of a four quadrant exercise. In this exercise the subject stands on a single limb and hops across and diagonal into the corresponding quadrants, holding each position for three seconds. The subject's ability to maintain stability is the sole measure for this exercise.[47] It is extremely important to attempt to eliminate the risk of injury during the implementation of prevention programs because subjects may sometimes be placed in positions their bodies are unfamiliar with.

Summary

The current estimations of 75,000 to 250,000 ACL injuries a year create a need for the implementation of NCACL prevention programs to reduce the incidence of this injury. Of these 75,000 to 250,000 ACL injuries, it has been suggested that 70% of them are considered noncontact.[1] The gluteus medius muscle has been identified as an important component of noncontact ACL injuries. It is considered important due to its primary function, which is to abduct the hip and internally rotate the thigh.[16,17] The strengthening of the gluteus medius muscle may help in the prevention of a functional medial collapse, which could lead to damaging the ACL.[3] There is currently a large amount of research focusing on female athletes and a higher incidence of injury compared to males. Regardless of which gender is more at risk, it is important to identify strength training programs that can aid in the reduction of ACL injuries. Current programs in use need to be tested to observe their effectiveness in related musculature as well as their value between genders.

APPENDIX B

The Problem

Statement of the Problem

The purpose of the study is to examine the effect of an ACL injury prevention program on gluteus medius strength between males and females. It is important to examine this relationship because current research shows a direct relationship between the strength of the gluteus medius and ACL injuries. Strengthening the gluteus medius may aid in the reduction of stressors in the lower extremity due to joint malalignment. It is also important to determine if males and females benefit similarly to determine if there is a need for more or less gender specific ACL injury prevention programs. The knowledge gained from this study may be beneficial to those looking to prevent ACL injuries. We do not know if there will be significant gains in gluteus medius strength through the use of the Trunk Neuromuscular Training Program, and we also do not know if there will be a difference in the benefits gained between the genders.

Definition of Terms

The following definitions of terms will be defined for this study:

1) ACL Prevention Program – A program that is designed to prevent an injury of the anterior cruciate ligament

through the use of neuromuscular and proprioceptive training techniques.

2) Physically active college aged students – Study participant that engages in physical activity for at least 30 minutes three times a week and are aged between 18 and 26.

3) Lafayette Manual Muscle Test System (MMTS) – a device used to objectively measure muscle strength.

Basic Assumptions

The following are basic assumptions of this study:

1) All subjects will follow the exercise protocol they have been assigned.

2) The subjects will put forth a maximal effort during their exercise sessions and during strength testing.

3) The subjects will be honest in their completion of the demographic forms.

4) All testing instruments are valid and reliable tools that are used for their intended purpose.

5) Subjects for the study are volunteers who were not coerced in any way to participate.

Limitations of the Study

The following are possible limitations of the study:

1) The number of participants involved in this study may not be large enough for significant results.
2) Findings are limited to active, college-aged recreational student athletes.
3) The six week time limit for the implementation of the exercises programs may not be long enough for significant results to be achieved.

Significance of the Study

Anterior cruciate ligament injuries are among the most devastating injuries that can be sustained by athletes. Currently, it is estimated that between 75,000 and 250,000 ACL injuries occur each year. The gluteus medius muscle provides an important role in preventing lower extremity injuries through stabilization of the pelvis. The stabilization of the pelvis contributes to preventing a valgus collapse of the knee, which is characterized by internal rotation of the femur, knee valgus, and ankle pronation. There are several ACL injury prevention programs that are currently available to the public. This study uses an ACL injury prevention program to test it’s effects on the gluteus medius muscle between males and females. Current research indicates a higher incidence of ACL injuries in the female population when compared to males. For this reason, many prevention programs have been tailored to the female population. It is crucial to determine if males and females both benefit similarly from currently available ACL injury prevention programs. The information gained from this study may provide future researchers with an understanding of what programs provide the best results. The information gained from this study may also show that there may be a need for more or less gender specific ACL injury prevention programs.

APPENDIX C

Additional Methods

APPENDIX C1

Informed Consent Form

California University of Pennsylvania

Informed Consent Form

1. Jordan Blair, who is a Graduate Athletic Training Student at California University of Pennsylvania, has requested my participation in a research study at California University of Pennsylvania. The title of the research is *The Effect of an ACL Injury Prevention Program on Gluteus Medius strength between Genders*

2. I have been informed that the purpose of this study is to examine the effect of an ACL injury prevention program on gluteus medius strength between males and females. I understand that I must be 18 years of age or older to participate. I understand that I have been asked to participate along with 31 other individuals because I am physically active, as defined as participating in moderate to intense exercise at least 3 times a week

3. I have been invited to participate in this research project. My participation is voluntary and I can choose to discontinue my participation at any time without penalty or loss of benefits. My participation will involve pre and post testing to occur before and after the implementation of either the Trunk Neuromuscular Training (TNT) program over six weeks or no exercise assignment over six weeks. I acknowledge that the TNT program will involve an exercise session to meet two times a week taking approximately 25 minutes to complete including the exercises associated with the program as well as a warm up. I also acknowledge that these exercises will be demonstrated to me on the first day of my exercise program.

4. I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. With participation in a research program such as this there is always the potential for unforeseeable risks as well. I understand that the risks I may be exposed to include, but are not limited to, soreness associated with exercise as well as injuries that may be sustained during normal bouts of physical activity that involve the lower extremity.

5. I understand that, in case of injury, I can expect to receive treatment or care in Hamer Hall's Athletic Training Facility. This treatment will be provided by the researcher, Jordan Blair, under the supervision of the CalU athletic training faculty, all of which can administer emergency care. Additional services needed for prolonged care will be referred to the attending staff at the Downey Garofola Health Services located on campus.

6. There are no feasible alternative procedures available for this study.

7. I understand that the possible benefits of my participation in the research is to contribute to existing research and may aid in the enhancement of ACL injury prevention programs.

8. I understand that the results of the research study may be published but my name or identity will not be revealed. Only aggregate data will be reported. In order to maintain confidentially of my records, Jordan Blair will maintain all documents in a secure location on campus and password protect all electronic files so that only the student researcher and research advisor can access the data. Each subject will be given a specific subject number to represent his or her name so as to protect the anonymity of each subject.

9. I have been informed that I will not be compensated for my participation.

10. I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by:

Jordan Blair, ATC
STUDENT/PRIMARY RESEARCHER
Bla5790@calu.edu
412-477-5657

Shelly DiCesaro, PhD, ATC, CSCS
RESEARCH ADVISOR
Dicesaro@calu.edu
724-938-5831

11. I understand that written responses may be used in quotations for publication but my identity will remain anonymous.

12. I have read the above information and am electing to participate in this study. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me upon request.

13. This study has been approved by the California University of Pennsylvania Institutional Review Board.

14. The IRB approval dates for this project are from: 02/24/11 to 02/23/12.

Subject's signature:_________________________________
Date:___________________
Witness signature:_________________________________
Date:___________________

APPENDIX C2

Institutional Review Board –

California University of Pennsylvania

Proposal Number
Date Received

California University of Pennsylvania

PROTOCOL for Research Involving Human Subjects

Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects

(Reference IRB Policies and Procedures for clarification)

Project Title ***The Effect an ACL Injury Prevention Program on Gluteus Medius Strength Between Genders***

Researcher/Project Director ***Jordan Blair***

Phone # ***412-477-5657*** ***E-mail Address*** ***BLA5790@calu.edu***

Faculty Sponsor (if required) ***Dr. Shelly Dicesaro***

Department ***Health Science***

Project Dates ***January 2011*** ***to*** ***June 2011***

Sponsoring Agent (if applicable) -

Project to be Conducted at *California University of Pennsylvania*

Project Purpose: ☒ ***Thesis*** ☐ ***Research*** ☐ ***Class Project*** ☐ ***Other***

Keep a copy of this form for your records.

<u>Please attach a typed, detailed summary of your project AND complete items 2 through 6.</u>

1. *Provide an overview of your project-proposal describing what you plan to do and how you will go about doing it. Include any hypothesis(ses)or research questions that might be involved and explain how the information you gather will be analyzed. For a complete list of what should be included in your summary, please refer to Appendix B of the IRB Policies and Procedures Manual.*

   The purpose of this study is to examine the effects of an ACL injury prevention program on gluteus medius strength between males and females. Physically active students, ages 18 to 26, from California University of Pennsylvania are expected to participate in this study (N~32). Subjects that are currently suffering or recovering from a lower extremity injury sustain within the past 6 months will not be included in this study. The subjects who sign the informed consent will be randomly assigned into two separate groups (N~16) consisting of equal numbers of males (N~8) and females (N~8). One group will be the experimental group that will be given the pre test, prevention program, and post-test, while the other group will be the control that will only receive the pre-test and post-test. Gluteus medius strength will be measured before and after the implementation of the ACL injury prevention program, using the hand held Lafayette Manual Muscle Test System (MMTS), which is a small hand-held device that is placed over top of the muscle during a contraction to provide an objective measure of muscle strength. Testing will be done on both legs. For the muscle test, the subjects will lay on the opposite side that is being tested and the MMTS will be placed over the gluteus medius, which is located on the side of their hip. The subjects will then gradually push as hard as they can against the MMTS which will be in the researcher's hand. The pre-test measurement will provide a baseline from which to observe the effect of the program on gluteus medius compared to the control group. Demonstrations of each exercise will be done the first day of subject's participation to familiarize the subjects with the exercises. The researcher will also be available during the scheduled time for the subjects exercise sessions. Exercise sessions will be formulated based on the schedules of the subjects as well as the researcher. A log book will be kept to ensure attendance of the subjects. If any subject misses more than two scheduled exercises sessions or two sessions in a row they will be excluded from the study. Pictures and descriptions of all exercises from the program are attached. The following hypotheses will be investigated during this study; the trunk neuromuscular training program will significantly increase gluteus medius strength when compared to the control group. All data that is collected will be analyzed by SPSS for windows version 17.0 at an alpha level of .05 using a two way ANOVA.

2. *Section 46.11 of the Federal Regulations state that research proposals involving human subjects must satisfy certain requirements before the IRB can grant approval. You should describe in detail how the following requirements will be satisfied. Be sure to address each area separately.*

   a. *How will you insure that any risks to subjects are minimized? If there are potential risks, describe what will be done to minimize these risks. If there are risks, describe why the risks to participants are reasonable in relation to the anticipated benefits.*

      The potential risks involved will be outlined in the Informed Consent form and include delayed onset muscle soreness (DOMS), which is general muscle soreness and a common side effect of exercise, that may last two to three days. Other risks involve injuries that could be sustained during a normal exercise program involving the lower extremity including minor strains and sprains. Any injuries sustained during testing will be treated by the researcher or the researcher's advisor, both certified athletic trainers. To minimize the risk of injury, each group of subjects will be instructed on how to properly warm up and these warm ups will be incorporated into the ACL injury prevention program. Every exercise will be demonstrated, by the researcher, to the participants prior to the subjects beginning the exercise. Also, the researcher or an undergraduate athletic training student, who is certified in first aid and CPR, will be present for each exercise session to ensure proper form for each exercise is being implemented to reduce the risk of injury.

b. *How will you insure that the selection of subjects is equitable? Take into account your purpose(s). Be sure you address research problems involving vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons. If this is an in-class project describe how you will minimize the possibility that students will feel coerced.*

The selection of subjects will be done on a volunteer basis. Only students deemed physically active will be included in the study. Subjects are considered physically active if they exercise for at least 30 minutes 3 or more times a week. Subjects recruited for the study will be students in health science classes at California University of Pennsylvania. Announcements of ability to participate in the study will be made in health science classes as well as through E-mail. To avoid the feeling of coercion, students will be assured that they are not required to participate and should only do so if they desire.

c. *How will you obtain informed consent from each participant or the subject's legally authorized representative and ensure that all consent forms are appropriately documented? Be sure to attach a copy of your consent form to the project summary.*

An informed consent form, that the students will have ample time to read, will be signed and completed by the subjects during a meeting to take place before the implementation of the exercise program. Before the informed consent form is signed, participants will have ample time to ask any questions they may have. A copy of the form is attached.

d. *Show that the research plan makes provisions to monitor the data collected to insure the safety of all subjects. This includes the privacy of subjects' responses and provisions for maintaining the security and confidentiality of the data.*

All data will be collected by the researcher and placed in a secure cabinet known only to the researcher and research advisor. A key to the cabinet will be in sole possession of the researcher. Subjects will be assigned a number to maintain confidentiality.

3. *Check the appropriate box(es) that describe the subjects you plan to use.*

☒ *Adult volunteers*	☐ *Mentally Disabled People*
☒ *CAL University Students*	☐ *Economically Disadvantaged People*
☐ *Other Students*	☐ *Educationally Disadvantaged People*
☐ *Prisoners*	☐ *Fetuses or fetal material*
☐ *Pregnant Women*	☐ *Children Under 18*
☐ *Physically Handicapped People*	☐ *Neonates*

4. *Is remuneration involved in your project?* ☐ *Yes or* ☒ *No. If yes, Explain here.*

5. *Is this project part of a grant?* ☐ *Yes or* ☒ *No If yes, provide the following information:*

   Title of the Grant Proposal

   Name of the Funding Agency

   Dates of the Project Period

6. *Does your project involve the debriefing of those who participated?* ☐ *Yes or* ☒ *No*

   If Yes, explain the debriefing process here.

7. *If your project involves a questionnaire interview, ensure that it meets the requirements of Appendix___in the Policies and Procedures Manual.*

California University of Pennsylvania Institutional Review Board
Survey/Interview/Questionnaire Consent Checklist (v021209)

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview or questionnaire?

☐ **YES**—Complete this form

☒ **NO**—You MUST complete the "Informed Consent Checklist"—skip the remainder of this form

Does your survey/interview/questionnaire cover letter or explanatory statement include:

☐ (1) Statement about the general nature of the survey and how the data will be used?

☐ (2) Statement as to who the primary researcher is, including name, phone, and email address?

☐ (3) FOR ALL STUDENTS: Is the faculty advisor's name and contact information provided?

☐ (4) Statement that participation is voluntary?

☐ (5) Statement that participation may be discontinued at any time without penalty and all data discarded?

☐ (6) Statement that the results are confidential?

☐ (7) Statement that results are anonymous?

☐ (8) Statement as to level of risk anticipated or that minimal risk is anticipated? (NOTE: If more than minimal risk is anticipated, a full consent form is required—and the Informed Consent Checklist must be completed)

☐ (9) Statement that returning the survey is an indication of consent to use the data?

☐ (10) Who to contact regarding the project and how to contact this person?

☐ (11) Statement as to where the results will be housed and how maintained? (unless otherwise approved by the IRB, must be a secure location on University premises)

☐ (12) Is there text equivalent to: "Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm"? (the actual dates will be specified in the approval notice from the IRB)?

☐ (13) FOR ELECTRONIC/WEBSITE SURVEYS: Does the text of the cover letter or
explanatory statement appear before any data is requested from the participant?

☐ (14) FOR ELECTONIC/WEBSITE SURVEYS: Can the participant discontinue participation at any point in the process and all data is immediately discarded?

California University of Pennsylvania Institutional Review Board
Informed Consent Checklist (v021209)

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview, or questionnaire?

☐ **YES**—DO NOT complete this form. You MUST complete the "Survey/Interview/Questionnaire Consent Checklist" instead.

☒ **NO**—Complete the remainder of this form.

1. Introduction (check each)

☒ (1.1) Is there a statement that the study involves research?

☒ (1.2) Is there an explanation of the purpose of the research?

2. Is the participant. (check each)

☒ (2.1) Given an invitation to participate?

☒ (2.2) Told why he/she was selected.

☒ (2.3) Told the expected duration of the participation.

☒ (2.4) Informed that participation is voluntary?

☒ (2.5) Informed that all records are confidential?

☒ (2.6) Told that he/she may withdraw from the research at any time without penalty or loss of benefits?

☒ (2.7) 18 years of age or older? (if not, see Section #9, Special Considerations below)

3. Procedures (check each).

☒ (3.1) Are the procedures identified and explained?

☒ (3.2) Are the procedures that are being investigated clearly identified?

☒ (3.3) Are treatment conditions identified?

4. Risks and discomforts. (check each)

☒ (4.1) Are foreseeable risks or discomforts identified?

☒ (4.2) Is the likelihood of any risks or discomforts identified?

☒ (4.3) Is there a description of the steps that will be taken to minimize any risks or discomforts?

☒ (4.4) Is there an acknowledgement of potentially unforeseeable risks?

☒ (4.5) Is the participant informed about what treatment or follow up courses of action are available should there be some physical, emotional, or psychological harm?

☒ (4.6) Is there a description of the benefits, if any, to the participant or to others that may be reasonably expected from the research and an estimate of the likelihood of these benefits?

☒ (4.7) Is there a disclosure of any appropriate alternative procedures or courses of treatment that might be advantageous to the participant?

5. Records and documentation. (check each)

☒ (5.1) Is there a statement describing how records will be kept confidential?
☒ (5.2) Is there a statement as to where the records will be kept and that this is a secure location?
☒ (5.3) Is there a statement as to who will have access to the records?

6. For research involving more than minimal risk (check each),
☒ (6.1) Is there an explanation and description of any compensation and other medical or counseling treatments that are available if the participants are injured through participation?
☒ (6.2) Is there a statement where further information can be obtained regarding the treatments?
☒ (6.3) Is there information regarding who to contact in the event of research-related injury?

7. Contacts.(check each)
☒ (7.1) Is the participant given a list of contacts for answers to questions about the research and the participant's rights?
☒ (7.2) Is the principal researcher identified with name and phone number and email address?
☒ (7.3) FOR ALL STUDENTS: Is the faculty advisor's name and contact information provided?

8. General Considerations (check each)
☒ (8.1) Is there a statement indicating that the participant is making a decision whether or not to participate, and that his/her signature indicates that he/she has decided to participate having read and discussed the information in the informed consent?
☒ (8.2) Are all technical terms fully explained to the participant?
☒ (8.3) Is the informed consent written at a level that the participant can understand?
☒ (8.4) Is there text equivalent to: "Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm"? (the actual dates will be specified in the approval notice from the IRB)

9. Specific Considerations (check as appropriate)
☐ (9.1) If the participant is or may become pregnant is there a statement that the particular treatment or procedure may involve risks, foreseeable or currently unforeseeable, to the participant or to the embryo or fetus?
☒ (9.2) Is there a statement specifying the circumstances in which the participation may be terminated by the investigator without the participant's consent?
☐ (9.3) Are any costs to the participant clearly spelled out?
☐ (9.4) If the participant desires to withdraw from the research, are procedures for orderly termination spelled out?

☐ (9.5) Is there a statement that the Principal Investigator will inform the participant or any significant new findings developed during the research that may affect them and influence their willingness to continue participation?

☐ (9.6) Is the participant is less than 18 years of age? If so, a parent or guardian must sign the consent form and assent must be obtained from the child

- ☐Is the consent form written in such a manner that it is clear that the parent/guardian is giving permission for their child to participate?
- ☐Is a child assent form being used?
- ☐ Does the assent form (if used) clearly indicate that the child can freely refuse to participate or discontinue participation at any time without penalty or coercion?

☒ (9.7) Are all consent and assent forms written at a level that the intended participant can understand? (generally, 8th grade level for adults, age-appropriate for children)

California University of Pennsylvania Institutional Review Board
Review Request Checklist (v021209)

This form MUST accompany all IRB review requests.
Unless otherwise specified, ALL items must be present in your review request.

Have you:

☐ (1.0) FOR ALL STUDIES: Completed ALL items on the Review Request Form? Pay particular attention to:

- ☒ (1.1) Names and email addresses of all investigators
  - ☒ (1.1.1) FOR ALL STUDENTS: use only your CalU email address)
  - ☒ (1.1.2) FOR ALL STUDENTS: Name and email address of your faculty research advisor
- ☒ (1.2) Project dates (must be in the future—no studies will be approved which have already begun or scheduled to begin before final IRB approval—NO EXCEPTIONS)
- ☐ (1.3) Answered completely and in detail, the questions in items 2a through 2d?
  - ☒2a: NOTE: No studies can have zero risk, the lowest risk is “minimal risk”. If more than minimal risk is involved you MUST:
    - ☒ i. Delineate all anticipated risks in detail;
    - ☒ ii. Explain in detail how these risks will be minimized;
    - ☒ iii. Detail the procedures for dealing with adverse outcomes due to these risks.
    - ☒ iv. Cite peer reviewed references in support of your explanation.
  - ☒ 2b. Complete all items.
  - ☒ 2c. Describe informed consent procedures in detail.
  - ☒ 2d. NOTE: to maintain security and confidentiality of data, all study records must be housed in a secure (locked) location ON UNIVERSITY PREMISES. The actual location (department, office, etc.) must be specified in your explanation and be listed on any consent forms or cover letters.
- ☐ (1.4) Checked all appropriate boxes in Section 3? If participants under the age of 18 years are to be included (regardless of what the study involves) you MUST:
  - ☐ (1.4.1) Obtain informed consent from the parent or guardian—consent forms must be written so that it is clear that the parent/guardian is giving permission for their child to participate.
  - ☐ (1.4.2) Document how you will obtain assent from the child—This must be done in an age-appropriate manner. Regardless of whether the parent/guardian has given permission, a child is completely free to refuse to participate, so the investigator must document how the child indicated agreement to participate (“assent”).

☐ (1.5) Included all grant information in section 5?
☐ (1.6) Included ALL signatures?

☐ (2.0) FOR STUDIES INVOLVING MORE THAN JUST SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:

☒ (2.1) Attached a copy of all consent form(s)?
☐ (2.2) FOR STUDIES INVOLVING INDIVIDUALS LESS THAN 18 YEARS OF AGE: attached a copy of all assent forms (if such a form is used)?
☒ (2.3) Completed and attached a copy of the Consent Form Checklist? (as appropriate—see that checklist for instructions)

☐ (3.0) FOR STUDIES INVOLVING ONLY SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:

☐ (3.1) Attached a copy of the cover letter/information sheet?
☐ (3.2) Completed and attached a copy of the Survey/Interview/Questionnaire Consent Checklist? (see that checklist for instructions)
☐ (3.3) Attached a copy of the actual survey, interview, or questionnaire questions in their final form?

☐ (4.0) FOR ALL STUDENTS: Has your faculty research advisor:

☒ (4.1) Thoroughly reviewed and approved your study?
☒ (4.2) Thoroughly reviewed and approved your IRB paperwork? including:
☒ (4.2.1) Review request form,
☒ (4.2.2) All consent forms, (if used)
☒ (4.2.3) All assent forms (if used)
☐ (4.2.4) All Survey/Interview/Questionnaire cover letters (if used)
☒ (4.2.5) All checklists
☐ (4.3) IMPORTANT NOTE: Your advisor's signature on the review request form indicates that they have thoroughly reviewed your proposal and verified that it meets all IRB and University requirements.

☒ (5.0) Have you retained a copy of all submitted documentation for your records?

Project Director's Certification
Program Involving HUMAN SUBJECTS

The proposed investigation involves the use of human subjects and I am submitting the complete application form and project description to the Institutional Review Board for Research Involving Human Subjects.

I understand that Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects. If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advice of the Board whenever I believe such advice is necessary or would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

Professional Research

Project Director's Signature | Department Chairperson's Signature

Student or Class Research

Student Researcher's Signature

Shelly DeCesaro PhD, ATC

Supervising Faculty Member's Signature if required

Department Chairperson's Signature

ACTION OF REVIEW BOARD (IRB use only)

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

☐ Approved[______________________] ☐ Disapproved

Chairperson, Institutional Review Board | Date

Approved, September 12, 2005 / (updated 02-09-09)

Institutional Review Board

California University of Pennsylvania

Psychology Department LRC, Room 310

250 University Avenue

California, PA 15419

instreviewboard@cup.edu

instreviewboard@calu.edu

Robert Skwarecki, Ph.D., CCC-SLP,Chair

Jordan Blair,

Please consider this email as official notification that your proposal titled "The Effect an ACL Injury Prevention Program on Gluteus Medius Strength Between Genders" (Proposal #10-029) has been approved by the California University of Pennsylvania Institutional Review Board as submitted, with the following stipulation:

- **A screening question or statement indicating that participants must be 18 years of age or older must be present in the consent form and/or questionnaire.**

Once you have made this revision, you may immediately begin data collection. You do not need to wait for further IRB approval. [At your earliest convenience, you must forward a copy of the revised consent form for the Board's records].

The effective date of the approval is 02-24-2011 and the expiration date is 02-23-2012. These dates must appear on the consent form .

Please note that Federal Policy requires that you notify the IRB promptly regarding any of the following:

(1) Any additions or changes in procedures you might wish for your study (additions or changes must be approved by the IRB before they are implemented)

(2) Any events that affect the safety or well-being of subjects

(3) Any modifications of your study or other responses that are necessitated by any events reported in (2).

(4) To continue your research beyond the approval expiration date of 02-23-2012 you must file additional information to be considered for continuing review. Please contact instreviewboard@cup.edu

Please notify the Board when data collection is complete.

Regards,

Robert Skwarecki, Ph.D., CCC-SLP

Chair, Institutional Review Board

Appendix C3

Trunk Neuromuscular Training Program

Trunk Neuromuscular Training Program

Progression 1	Time	Reps	Sets
Lateral Jump and Hold		8	
Step-Hold		8	R&L Legs
Bosu (Round) Swimmers		10	
BOSU (Round) Double Knee-Hold	20 sec		
Single Leg Lateral Airex Hop-Hold		4	R&L Legs
Single Truck Jump-Soft Landing		10	
Front Lunge		10	R&L Legs
Lunge Jumps	10 sec		R&L Legs
BOSU (FLAT) Double Leg Pelvic Bridges		10	
Single Leg 90 degree Hop-Hold		8	R&L Legs
BOSU (Round) Lateral Crunch		10	R&L Legs
Box Double Crunch		15	
Swiss Ball Back Hyperextensions		15	

Progression 2	Time	Reps	Sets
Lateral Jumps	10 sec		
Jump-Single Leg Hold		8	R&L Legs
BOSU (Round) Toe Touch Swimmers		10	R&L Legs
BOSU (Round) Single Knee-Hold	20 sec		R&L Legs
Single Leg Lateral BOSU (Round) Hop-Hold		8	R&L Legs
Double Tuck Jump		6	
Walking Lunges		10	
Scissor Jumps	10 sec		
BOSU (Flat) Single Leg Pelvic Bridges		10	R&L Legs
Single Leg 90 degree airex Hop-Hold		8	R&L Legs
Box Lateral Crunch		10	R&L Legs
Box Swivel Double Crunch		15	R&L Legs
Swiss Ball Back Hyperextensions with Ball Reach		15	

Progression 3	Time	Reps	Sets
Lateral Hop and Hold		8	R&L Legs
Hop-Hold		8	R&L Legs
Prone bridge (Elbow and Knees) Hip Extension Opposite Shoulder Flexion		10	
Swiss Ball Bilateral Kneel	20 sec		
Single Leg Lateral BOSU (Round) Hop-Hold with Ball Catch		4	R&L Legs
Repeated Tuck Jump	10 sec		
Walking Lunges Unilaterally weighted		10	R&L Legs
Lunge Jumps unilaterally Weighted	10 sec		R&L Legs
BOSU (Flat) Single Leg Pelvic Bridges with Ball Hold		10	R&L Legs
Single Leg 90 Degree Airex hop-Hold Reaction Ball Catch		6	R&L Legs
BOSU (Round) Lateral Crunch with Ball catch		8	R&L Legs
BOSU (Round) Swivel Ball Touches (Feet UP)		15	
Swiss Ball Hyperextensions with Back Fly		15	

Progression 4	Time	Reps	Sets
Lateral Hops	10 sec		R&L Legs
Hop-Hop-Hold		8	R&L Legs
Prone bridge (Elbow and toes) Hip Extension		10	R&L Legs
Swiss Ball Bilateral Kneel with Partner Pertubations	20 sec		
Single Leg 4 Way BOSU (Round) Hop-Hold		3 cycles	R&L Legs
Side to Side Barrier Tuck Jumps	10 sec		
Walking Lunges with Plate Cross-over		10	R&L Legs
Scissor Jumps Unilaterally Weighted	10 sec		R&L Legs
Supine Swiss Ball Hamstring Curl		10	
Single Leg 180 degree Airex Hop-Hold		8	R&L Legs
Swiss Ball Lateral Crunch		15	R&L Legs
BOSU (Round) double crunch		15	
Swiss Ball Hyperextensions with Ball Reach Lateral		15	R&L Legs

Progression 5	Time	Reps	Sets
X-Hops		6 cycles	R&L Legs
Crossover-Hop-Hop-Hold		8	R&L Legs
Prone bridge (Elbow and toes) Hip Extension opposite shoulder flexion		10	R&L Legs
Swiss Ball Bilateral Kneel with Lateral Ball Catch	20 sec		
Single Leg 4 Way BOSU (Round) Hop-Hold With Ball Catch		3 cycles	R&L Legs
Side to Side Reaction Barrier Tuck Jumps	10 sec		
Walking Lunges with Unilateral Shoulder Press		10	R&L Legs
Scissor Jumps with Ball Swivel	10 sec		R&L Legs
Swivel Russian Hamstring Curl		10	
Single Leg 180 degree Airex Hop-Hold Reaction Ball Catch		8	R&L Legs
Swiss Ball Lateral Crunch with Ball Catch		8	R&L Legs
BOSU (Round) Swivel Double Crunch		15	R&L Legs
Swiss Ball Hyperextensions with Lateral Ball Catch		15	

1. Lateral Jumping Progression

Phase I – Lateral Jump and Hold

The subject prepares for this exercise by standing with her feet close together and her knees slightly bent. The subject should jump laterally over a line keeping her knees bent and staying close to the line. When they lands on the opposite side, they should immediately descend into a deep hold.

Phase II – Lateral Jumps

The subject prepares for this exercise by standing with their feet close together and knees slightly bent on one side of the line. The subject should jump sideways over the line keeping her knees bent and staying close to the line.

When the subject lands on the opposite side, they should immediately redirect back to the initial position. The subject should repeat this sequence as quickly as they can while maintaining proper form. When teaching this exercise, encourage the subject to achieve as many repetitions as possible in the allotted time by jumping close to the lines, shortening the ground contact time, and not using excessive height on the jumps. Do not allow the subject to perform a double hop on the side of the line. Early in the training the subject may focus on the line, as their technique improves encourage them to shift their visual focus away from the line to outside cues.

Phase III – Lateral Hop and Hold

The subject prepares for this exercise by standing on one foot and their knee slightly bent. The subject should jump sideways over a line keeping their knee bent and staying close to the line. When they land on the opposite side, they should immediately descend into a single leg deep hold.

Phase IV – Lateral Hops

The subject prepares for this exercise by standing on one leg with their knee slightly bent on one side of the line. The subject should jump sideways over the line keeping their knee bent and staying close to the line. When the subject lands on the opposite side, they should immediately redirect back to the initial position. When teaching this exercise encourage the subject to achieve as many repetitions as possible in the allotted time by jumping close to the lines, shortening the ground contact time, and not using excessive height on the jumps. Do not allow the subject to perform a double hop on the side of the line.

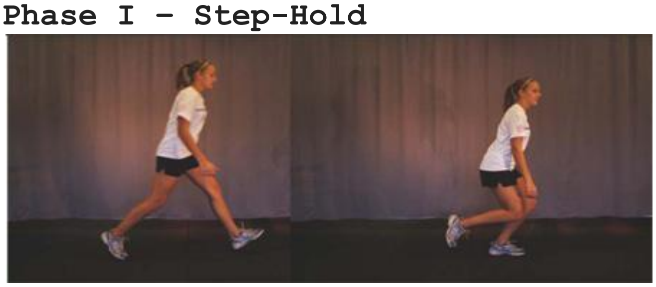
Early in the training the subject may focus on the line, as her technique improves encourage them to shift their visual focus away from the line to outside cues.

Phase V – X Hops

The subject begins facing a quadrant pattern standing on a single limb with their support knee slightly bent. They will hop diagonally, landing in the opposite quadrant, maintaining forward stance, and holding the deep knee flexion landing for three seconds. The subject then hops laterally into the side quadrant again holding the landing. Next, the subject will hop diagonally backwards holding the landing. Finally, they hop laterally into the initial quadrant holding the landing. The subject should repeat this figure 8 pattern for the required number of sets. Encourage the subject to maintain balance during each landing, keeping her eyes up and their focus away from their feet.

2. Single-Leg Anterior Progression

Phase I – Step-Hold



The subject starts by taking a quick step forward and continues by balancing in a deep hold position on the leg they stepped onto.

Phase II – Jump-Single Leg Hold

The subject will begin this exercise in the athletic position. The subject proceeds to jump forward, landing and balancing on one leg in a deep hold position.

Phase III – Hop-Hold

Starting in a balanced position on one foot, the subject hops forward, landing and balancing on one leg in a deep hold position.

Phase IV – Hop-Hop-Hold

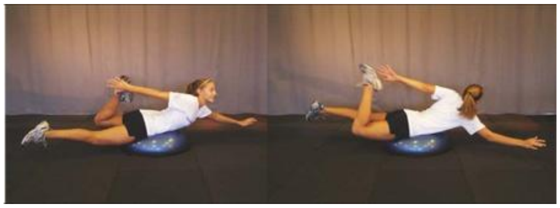
The subject hops forward twice quickly, landing and balancing on one leg in a deep hold position.

Phase V – Crossover-Hop-Hop-Hold

The subject hops forward while alternating legs three times quickly, landing and balancing on one leg in a deep hold position.

3. Prone Trunk Stability Progression

Phase I – BOSU® (Round) Toe Touch Swimmers



The subject begins in a prone position with their abdomen centered on the round side of the BOSU® and their arms overhead and legs extended. The subject reaches back with one arm to touch opposite foot and returns to the outstretched superman position

Phase II – BOSU® (Round) Swimmers with Partner Perturbations

The subject begins in prone position with abdomen centered on the round side of the BOSU® and with their arms overhead and legs extended. The movement is initiated by elevating the opposite arm and leg and held for three seconds. A partner will offer random perturbations by stepping on different sides of the BOSU® during the exercise.

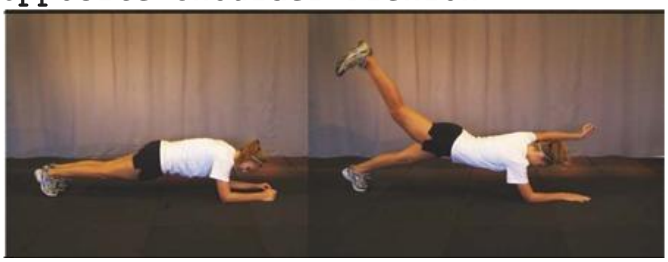
Phase III – Prone Bridge (Elbows and Knees) Hip Extension Opposed Shoulder Flexion

The subject begins in prone position with her elbows flexed and balanced on an Airex pad and knees on the ground. The movement is initiated by elevating the opposite arm and leg and held for a single count and finitheyd by returning to the original position.

Phase IV – Prone Bridge (Elbows and Toes) Hip Extension

The subject begins in prone position with elbows flexed and balanced on an Airex pad and toes on the ground. The movement is initiated by elevating the each leg individually and held for a single count and finished by returning to the original position.

Phase V – Prone Bridge (Elbows and Toes) Hip Extension Opposite Shoulder Flexion



The subject begins in prone position with elbows flexed and balanced on an Airex pad and toes on the ground. The movement is initiated by elevating the opposite arm and leg and held for a single count and finished by returning to the original position.

4. Kneeling Trunk Stability Progression

Phase I – BOSU® (Round) Double Knee-Hold

The subject begins this exercise by balancing in a kneeling position with their knees on each side of the round side of the BOSU®. The subject will maintain this balanced position with the hips slightly flexed for the duration of the exercise.

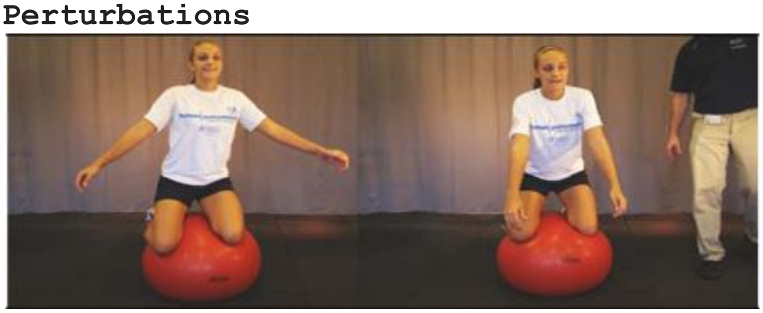
Phase II – BOSU® (Round) Single Knee-Hold

The subject begins this exercise by balancing in a kneeling position with one knee directly in the middle of the round side of the BOSU® and the other knee extended out to the side. The subject will maintain this balanced position with the hip slightly flexed for the duration of the exercise.

Phase III – Swiss Ball Bilateral Kneel

The subject kneels and balances on Swiss ball with feet off the ground. A spotter should be available at all times in front of the subject

Phase IV – Swiss Ball Bilateral kneel with Partner Perturbations



The subject kneels and balances on Swiss ball with their feet off of the ground. Once the subject is stabilized a partner can perturb the ball by kicking in unanticipated directions. A spotter should be available at all times in front of the subject.

Phase V – Swiss Ball Bilateral Kneel with Lateral Ball Catch

The subject kneels and balances on Swiss ball with feet off the ground. A ball should be tossed back and forth with a partner to increase the difficulty of this exercise. A spotter should be present next to the subject at all times.

5. Single Leg Lateral Progression

Phase I – Single Leg Lateral AIREX Hop-Hold

Subject starts on one side of the Airex pad and hops laterally onto the Airex. The subject should maintain balance and hold the knee in a flexed position. The subject then hops off the other side of the Airex onto the ground, maintains balance and then repeats the exercise in the other direction.

Phase II – Single Leg Lateral BOSU® (Round) Hop-Hold

Subject starts on one side of the BOSU® and hops laterally onto the BOSU®. The subject should maintain balance and hold the knee in a flexed position. The subject then hops off the other side of the BOSU® onto the ground, maintains balance and then repeats the exercise in the other direction.

Phase III – Single Leg Lateral BOSU® (Round) Hop-Hold with Ball Catch

The subject starts on one side of the BOSU® and hops laterally onto the BOSU®. The subject should maintain balance and hold the knee in a flexed position. The subject then hops off the other side of the BOSU® onto the ground, maintains balance and then repeats the exercise in the other direction. The subject is further challenged by having to catch and return a ball upon each landing.

Phase IV – Single Leg 4 Way BOSU® (Round) Hop-Hold

The subject starts in a single leg athletic position immediately behind the BOSU®. The subject hops forward onto the round side of the BOSU® and lands in a balanced position. After achieving a balanced single leg stance on the BOSU®, the subject proceeds to hop off the BOSU® laterally and assumes this same stance on the floor immediately next to the BOSU®. The subject will then continue to hop on and off the BOSU®, achieving a balanced athletic position, in each of the four directions: forward, backwards, lateral and medial.

Phase V – Single Leg 4 Way BOSU® (Round) Hop-Hold with Ball Catch

The subject starts in a single leg athletic position immediately behind the BOSU®. The subject hops forward onto the round side of the BOSU® and lands in a balanced position. After achieving a balanced single leg stance on the BOSU®, the subject proceeds to hop off the BOSU® laterally and assumes this same stance on the floor immediately next to the BOSU®. The subject will then continue to hop on and off the BOSU®, achieving a balanced athletic position, in each of the four directions: forward, backwards, lateral and medial. A ball should be tossed back and forth with a partner upon landing to increase the difficulty of this exercise.

6. Tuck Jump Progression

Phase I - Single Tuck Jump Soft Landing

The subject starts in the athletic position with their feet shoulder width apart. The subject initiates a vertical jump with a slight crouch downward while they extends their arms behind them. The subject then swings their arms forward as they simultaneously jumps straight up and pulls their knees up as high as possible. At the highest point of the jump the subject should be positioned in the air with their thighs parallel to the ground. On landing, the subject should land softly, using a toe to mid-foot rocker landing. The subject should not continue this jump if they cannot control the high landing force or keep their knees aligned during landing. If the subject is unable to raise the knees to the proper height, it may be valuable to instruct them to "grasp the knees and they bring the thighs to horizontal."

Phase II – Double Tuck Jump

Similar to the single tuck jump described above but with an additional jump performed immediately after the first jump. The subject should focus on maintaining good form and minimizing time on the ground between jumps.

Phase III – Repeated Tuck Jumps

The subject starts in the athletic position with their feet shoulder width apart. The subject initiates a vertical jump with a slight crouch downward while they extends their arms behind them. The subject then swings their arms forward as they simultaneously jump straight up and pull their knees up as high as possible. At the highest point of the jump the subject should be positioned in the air with their thighs parallel to the ground. When landing the subject should immediately begin the next tuck jump.

Phase IV – Side to Side Tuck Jumps

The subject starts in the athletic position with their feet shoulder width apart. The subject initiates a vertical jump over a barrier with a slight crouch downward while they extends their arms behind them. The subject then swings their arms forward as they simultaneously jump straight up and pull their knees up as high as possible. At the highest point of the jump the subject should be positioned in the air with their thighs parallel to the ground. When landing, the subject should immediately begin the next tuck jump back to the other side of the barrier.

Phase V – Side to Side Reaction Barrier Tuck Jumps

The subject starts in the athletic position with their feet shoulder width apart. The subject initiates a vertical jump over a barrier with a slight crouch downward while they extend their arms behind them. The subject then swings their arms forward as they simultaneously jump straight up and pull their knees up as high as possible. At the highest point of the jump the subject should be positioned in the air with their thighs parallel to the ground. When landing the subject should immediately begin the next tuck jump. When prompted, the subject should jump to the other side of the barrier without breaking rhythm.

7. Lunge Progression

Phase I – Front Lunges

The subject begins by stepping forward from a standing position. The step should be exaggerated in length to the point that their front leg is positioned with the knee flexed to 90° and the lower leg completely vertical. The back leg should be as straight as possible and the torso upright. Emphasis should be placed on getting the hips as low as possible while maintaining the previously described body position. The exercise is completed by driving off the front leg and returning to the original position.

Phase II – Walking Lunges

The subject performs a lunge and instead of returning to the start position they step through with the back limb and proceed forward with a lunge on the opposite limb. Encourage the subject to lunge their front limb far enough out so that their knee does not advance beyond their ankle during the exercise. An alternative coaching method is to instruct the subject to attempt to maintain a constant low center of gravity and roll through the lunges. This increases the intensity of the exercise and attempts to mimic motions frequently occurring in sports.

Phase III – Walking Lunges Unilaterally Weighted

The subject performs a lunge and instead of returning to the start position they steps through with the back limb and proceeds forward with a lunge on the opposite limb while holding a dumbbell in one hand. Encourage the subject to lunge their front limb far enough out so that their knee does not advance beyond her ankle during the exercise. This exercise is then repeated with the dumbbell in the opposite hand.

Phase IV – Walking Lunges with Plate Crossover

The subject performs a lunge and instead of returning to the start position they steps through with the back limb and proceeds forward with a lunge on the opposite limb while reaching with a weight plate to the open side of the body. Encourage the subject to lunge their front limb far enough out so that their knee does not advance beyond her ankle during the exercise.

Phase V – Walking Lunges with Unilateral Shoulder Press

The subject performs a lunge and instead of returning to the start position they steps through with the back limb and proceeds forward with a lunge on the opposite limb while pressing a dumbbell above her head. The weight should move up and down with the same tempo and direction as the lunge. Encourage the subject to lunge their front limb far enough out so that their knee does not advance beyond their ankle during the exercise.

8. Lunge Jump Progression

Phase I – Lunge Jumps

The subject starts in an extended stride position with the hips pushed forward, and the front knee positioned directly above the ankle and flexed to 90°. The back leg is fully extended at the hip and knee providing minimal support for the stance. The subject should jump vertically off of the front support leg maintaining the starting position during flight and landing. The jump is repeated as quickly as possible while still achieving maximum vertical height. To coach this jump, encourage the subject to keep the back leg straight and use it only for balance support. Vertical power is obtained by the front leg. Stance support percentages are approximately 80% for the front leg and 20% for the back.

Phase II – Scissor Jumps

The subject starts in an extended stride position with the hips pushed forward, and the front knee positioned directly above the ankle and flexed to 90°. The back leg is fully extended at the hip and knee providing minimal support for the stance. The subject should jump vertically off of the front support leg and switch the position of the legs while in flight. The jump is repeated as quickly as possible while still achieving maximum vertical height. The subject will be jumping off alternate legs on each jump during this exercise.

Phase III – Lunge Jumps Unilaterally Weighted

The subject starts in an extended stride position with their hips pushed forward, and the front knee positioned directly above the ankle and flexed to 90°. The back leg is fully extended at the hip and knee providing minimal support for the stance. The subject should jump vertically off of the front support leg maintaining the starting position during flight and landing. The jump is repeated as quickly as possible while still achieving maximum vertical height. To unilaterally weight this exercise a dumbbell should be held in one hand. This exercise is then repeated with the dumbbell in the opposite hand.

Phase IV – Scissor Jumps Unilaterally Weighted

The subject starts in an extended stride position with the hips pushed forward, and the front knee positioned directly above the ankle and flexed to 90°. The back leg is fully extended at the hip and knee providing minimal support for the stance. The subject should jump vertically off of the front support leg and switch the position of the legs while in flight. The jump is repeated as quickly as possible, while still achieving maximum vertical height. To unilaterally weight this exercise, a dumbbell should be held in one hand. The subject will be jumping off alternate legs on each jump during this exercise. This exercise is then repeated with the dumbbell in the opposite hand.

Phase V – Scissor Jumps with Ball Swivel

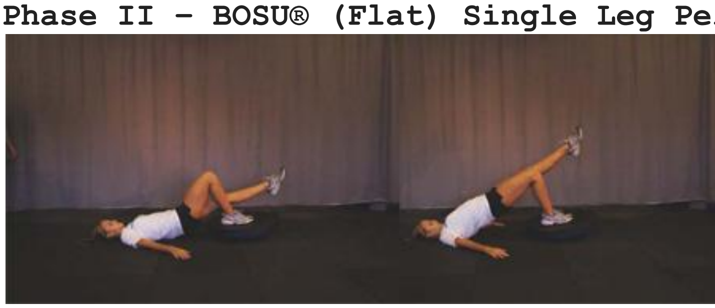
The subject starts in an extended stride position with the hips pushed forward, and the front knee positioned directly above the ankle and flexed to 90°. The back leg is fully extended at the hip and knee providing minimal support for the stance. The subject should jump vertically off of the front support leg and switch the position of the legs while in flight. The jump is repeated as quickly as possible while still achieving maximum vertical height. To unilaterally weight this exercise, a medicine ball should be swiveled to the open side of the body during each jump. The subject will be jumping off alternate legs

9. Hamstring Specific Progression

Phase I – BOSU® (Flat) Pelvic Bridge

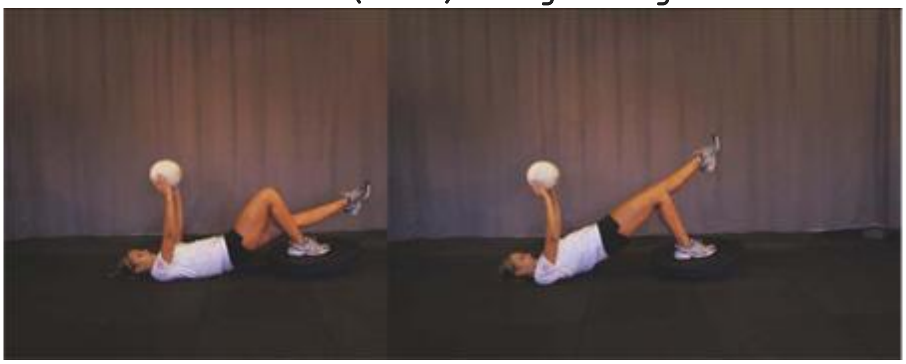
The subject lays supine with their hip and knees flexed and their feet planted on the flat side of the BOSU®. The subject then extends their hips and elevates their trunk off the ground to execute a pelvic bridge. This position should be held for 3 seconds prior to repeating the next repetition.

Phase II – BOSU® (Flat) Single Leg Pelvic Bridge



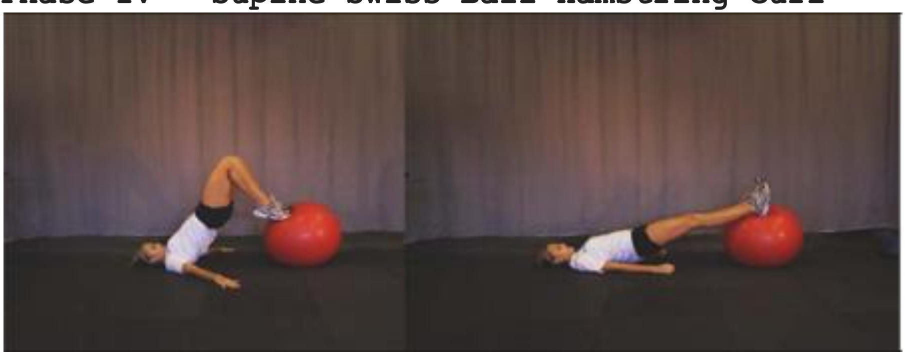
The subject lays supine with their hip and knees flexed and a single foot planted on the flat side of the BOSU® and the contralateral (opposite) leg fully extended. The subject then extends their hips and elevates their trunk off the ground to execute a pelvic bridge. This position should be held for 3 seconds prior to repeating the next repetition.

Phase III – BOSU® (Flat) Single Leg Pelvic Bridge



The subject lays supine with their hip and knees flexed and a single foot planted on the flat side of the BOSU® and the contralateral (opposite) leg fully extended holding a ball directly above her in her hands. The subject then extends their hips and elevates their trunk off the ground to execute a pelvic bridge. This position should be held for 3 seconds prior to repeating the next repetition.

Phase IV – Supine Swiss Ball Hamstring Curl



The subject lays supine with their hip and knees flexed with both heels planted on top of a Swiss ball. The subject then extends their hips and elevates their trunk off the ground while pulling her heels in to her buttocks.

Phase V – Russian Hamstring Curl with Lateral Touch

The subject begins in a kneeling position with a partner providing foot support and torso support (with band assistance). The subject extends at the knee to lower their torso towards the ground. Once touching the BOSU® with their chest the subject swivels their trunk and returns to the original position. The coach should provide enough assistance so that the exercise can be performed without flexing at the hip.

10. Single Leg Rotatory progression

Phase I – Single Leg 90° Hop-Hold

The starting position for this jump is with the subject in a semi-crouched position on the single limb being trained. The jump should focus on attaining maximum height while maintaining good form upon landing. During the flight phase, the subject should rotate 90°. The landing occurs on the same leg and should be performed with deep knee flexion (to 90°). The landing should be held for a minimum of three seconds to be counted as a successful landing. Coach this jump with care to protect the subject from injury. Start the subject with a sub maximal effort so they can experience the difficulty of the jump. Continue to increase the intensity of the jump as the subject improves their ability to stick and hold the final landing. Have the subject keep their focus away from their feet, to help prevent too much forward lean.

Phase II – Single Leg 90° AIREX Hop-Hold

The starting position for this jump is with the subject in a semi-crouched position on the single limb being trained.

The jump should focus on attaining maximum height while maintaining good form upon landing. During the flight phase the subject should rotate 90°. The landing occurs on the same leg and should be performed with deep knee flexion (to 90°). The landing should be held for a minimum of three seconds on an AIREX pad to be counted as a successful landing. Coach this jump with care to protect the subject from injury.

Phase III – Single Leg 90° Hop-Hold Reaction Ball Catch

The starting position for this jump is with the subject in a semi-crouched position on the single limb being trained. The jump should focus on attaining maximum height while maintaining good form upon landing. During the flight phase the subject should rotate 90°. The landing occurs on the same leg and should be performed with deep knee flexion (to 90°). The landing should be held for a minimum of three seconds on an AIREX pad to be counted as a successful landing. Upon landing a ball will be passed back and forth with the subject to increase the difficulty of a successful landing.

Phase IV – Single Leg 180° AIREX Hop-Hold

The starting position for this jump is with the subject in a semi-crouched position on the single limb being trained. The jump should focus on attaining maximum height while maintaining good form upon landing. During the flight phase the subject should rotate 180°. The landing occurs on the same leg and should be performed with deep knee flexion (to 90°). The landing should be held for a minimum of three seconds on an AIREX pad to be counted as a successful landing.

Phase V – Single Leg 180° AIREX Hop-Hold Reaction Ball Catch

The starting position for this jump is with the subject in a semi-crouched position on the single limb being trained. The jump should focus on attaining maximum height while maintaining good form upon landing. During the flight phase the subject should rotate 180°. The landing occurs on the same leg and should be performed with deep knee flexion (to 90°). The landing should be held for a minimum of three seconds on an AIREX pad to be counted as a successful landing. Upon landing a ball will be passed back and forth with the subject to increase the difficulty of a successful landing.

11. Lateral Trunk Progression

Phase I – BOSU® (Round) Lateral Crunch

The subject starts lying on their side with their hip located in the center of the round side of the BOSU®. The subject’s feet and legs must be anchored during this exercise by the trainer or a stationary object. The subject will proceed to bend laterally at the waist back and forth for the prescribed repetitions.

Phase II – Box Lateral Crunch

Subject starts in a supine position on a plyo box with arms placed on the back of the head. The subject flexes their trunk simultaneous with their flexion. As the trunk and hip are maximally flexed, the subject rotates at the trunk touching each elbow to the opposite knee.

Phase III – BOSU® (Round) Lateral Crunch with Ball Catch

Subject starts lying on side with hip located top of the round side of a BOSU®. The subject's feet and legs must be anchored during this exercise by the trainer or a stationary object. The subject will proceed to bend laterally at the waist back and forth for the prescribed repetitions. A ball should be tossed back and forth with a partner to increase the difficulty of this exercise.

Phase IV – Swiss Ball Lateral Crunch

Subject starts lying on side with hip located top of a Swiss ball. The subject's feet and legs must be anchored during this exercise by the trainer or a stationary object. The subject will proceed to bend laterally at the waist back and forth for the prescribed repetitions.

Phase V – Swiss Ball Lateral Crunch with Ball Catch

Subject starts lying on side with hip located top of a Swiss ball. The subject's feet and legs must be anchored during this exercise by the trainer or a stationary object. The subject will proceed to bend laterally at the waist back and forth for the prescribed repetitions. A ball should be tossed back and forth with a partner to increase the difficulty of this exercise.

12. Trunk Flexion Progression

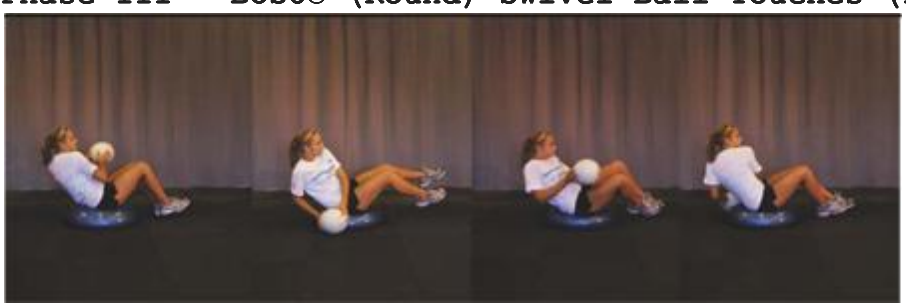
Phase I – Box Double Crunch

The subject starts out supine on a plyometric box or similar object and flexes their trunk simultaneous with hip flexion.

Phase II – Box Swivel Double Crunch

Subject starts in a supine position on a plyo box with arms placed across chest. The subject flexes their trunk simultaneous with hip flexion. As the trunk and hip are maximally flexed, the subject rotates at the trunk touching each elbow to the opposite knee.

Phase III – BOSU® (Round) Swivel Ball Touches (Feet up)



Subject starts sitting on the round side of a BOSU® holding a medicine ball. The subject will proceed to swivel at the trunk to touch the medicine ball to the floor for each repetition.

Phase IV – BOSU® (Round) Double Crunch

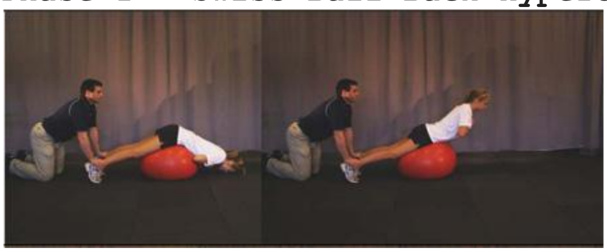
Subject starts sitting on the round side of a BOSU®. The subject flexes their trunk simultaneous with hip flexion.

Phase V – BOSU® (Round) Swivel Double Crunch

Subject starts sitting on the round side of a BOSU®. The subject flexes her trunk simultaneous with hip flexion. As the trunk and hip are maximally flexed, the subject rotates at the trunk touching each elbow to the opposite knee.

13. Trunk Extension Progression

Phase I – Swiss Ball Back Hyperextensions



The subject begins in a prone position on the Swiss ball with their hips centered on top of the Swiss ball and a partner anchoring their feet to the floor. The movement is initiated by extending htheirer hips and lower back to bring the subject into a position of slight hyperextension. The position should be maintained for a short pause and then returned to the flexed position.

Phase II – Swiss Ball Back Hyperextensions with Ball Reach

The subject begins in a prone position on the Swiss ball with their hips centered on top of the Swiss ball and a partner anchoring their feet to the floor. The movement is initiated by extending hips and lower back to bring the subject into a position of slight hyperextension. While performing this motion the subject will also extend and return a medicine ball from the chest to full shoulder and elbow extension and back to the chest.

Phase III – Swiss Ball Hyperextensions with Back Fly

The subject begins in a prone position on the Swiss ball with their hips centered on top of the Swiss ball and a partner anchoring their feet to the floor. The movement is initiated by extending hips and lower back to bring the subject into a position of slight hyperextension. The position should be maintained while the subject brings dumbbells out to the side similar to a back fly exercise.

Phase IV – Swiss Ball Hyperextensions with Ball Reach Lateral

The subject begins in a prone position on the Swiss ball with their hips centered on top of the Swiss ball and a partner anchoring their feet to the floor. The movement is initiated by extending hips and lower back to bring the subject into a position of slight hyperextension. The position should be maintained while the subject brings a medicine ball above their head and slightly to the side.

Phase V – Swiss Ball Hyperextensions with Lateral Ball Catch

The subject begins in a prone position on the Swiss ball with their hips centered on top of the Swiss ball and a partner anchoring their feet to the floor. The movement is initiated by extending hips and lower back to bring the subject into a position of slight hyperextension. The position should be maintained while the subject brings a medicine ball above her head and slightly to the side. A ball should be tossed back and forth with a partner to increase the difficulty of this exercise

Appendix C4
Physical Activity Readiness Questionnaire

Physical Activity Readiness Questionnaire (PAR-Q) and You

Regular physical activity is fun and healthy, and increasingly more people are starting to become more
active every day. Being more active is very safe for most people. However, some people should check with
their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the
seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you
should check with your doctor before you start. If you are over 69 years of age, and you are not used to being
very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully
and answer each one honestly:

YES NO
..1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
..2. Do you feel pain in your chest when you do physical activity?
..3. In the past month, have you had chest pain when you were not doing physical activity?
..4. Do you lose your balance because of dizziness or do you ever lose consciousness?
..5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
..6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
..7. Do you know of any other reason why you should not do physical activity?

NO to all questions Delay becoming much more active:
.If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
.If you are or may be pregnant – talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional.

Ask whether you should change your physical activity plan if you answered: YES to one or more questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
.Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.

.Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal.

Tell your doctor about the PAR-Q and which questions you answered YES.
.You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
.Find out which community programs are safe and helpful for you.

Informed use of the PAR-Q: Reprinted from ACSM’s Health/Fitness Facility Standards and Guidelines, 1997 by American College of Sports Medicine

Appendix C5

Demographic Information

Demographic Information

Subject #_______

Age: ___________________________

Year school: ___________________

Gender: Male or Female (Circle one)

Do you participate in Physical activity for 30 minutes at least three times a week? Yes or No (Circle One)

Which leg do you kick a ball with?
Right or Left (Circle One)

Have you sustained a lower extremity injury within the past 6 months?
Yes Or No (Circle One)

Do you suffer from any neuromuscular disorders that you know of?
Yes Or No (Circle One)

Do you have any balance problems?
Yes Or No (Circle One)

Has a doctor ever told you to not exercise?
Yes Or No (Circle One)

Do you have any other health conditions?
Yes Or No (Circle One)
If Yes, please explain:____
____
____
____

Appendix C6
Subject Testing Sheet

Subject Testing Sheet

Subject #_______
Gender_______
Group_______

Gluteus Medius Peak Force (lbs)

Distance from hip to knee__________m

Weight_________(lbs)/ =___________kg

	Practice Trial	Trial 1	Trial 2	Trial 3	Mean Peak force
Left Leg					
Right Leg					

Equation

Left Mean Peak Force (____________lbs) x 4.45 = ______________N

Right Mean Peak Force (______________lbs) x 4.45=_______________N

Gluteus Medius Peak Force (lbs)

Distance from hip to knee__________m

Weight_________(lbs)/ =___________kg

	Practice Trial	Trial 1	Trial 2	Trial 3	Mean Peak force
Left Leg					
Right Leg					

Equation

Left Mean Peak Force (____________lbs) x 4.45 = ______________N

Right Mean Peak Force (______________lbs) x 4.45=_______________N

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ABSTRACT

Title: THE EFFECT OF AN ACL INJURY PREVENTION PROGRAM ON GLUTEUS MEDIUS STRENGTH BETWEEN GENDERS

Researcher: Jordan Blair

Advisor: Dr. Shelly DiCesaro

Date: May 2011

Research Type: Master’s Thesis

Context: Current research indicates the gluteus medius as an important muscle in the prevention of ACL injuries. Previous studies have not examined the effects of an ACL injury prevention programs’ effect on gluteus medius strength, nor if there is a difference in benefits received from an ACL injury prevention program between genders.

Objective: The purpose of this study was to examine the effect of an ACL injury prevention program on gluteus medius strength as well as strength gains from the implementation of the program between males and females.

Design: Quasi-experimental pre-test and post-test.

Setting: Testing was performed in a controlled laboratory setting by the researcher.

Participants: Twenty-four physically active college students (male=12, female=12) that were injury free volunteered for this study.

Interventions: Subjects were randomly placed into an experimental or control group. All subjects’ gluteus medius strength was tested bilaterally at the beginning and end of a six week period in which the experimental group underwent an ACL injury prevention training protocol for 12 sessions twice a week.

Main Outcome Measures:

Gluteus medius strength was assessed at the end of the six weeks and compared between experimental and control groups as well as males and females in the experimental group.

Results: A significant difference in gluteus medius strength was found between the experimental and control groups ($t = 2.697$, $p = .016$). There was not a significant difference in gluteus medius strength between genders in the experimental group ($t = -0.665$, $p = 0.527$).

Conclusion: The implementation of a six week ACL injury prevention program significantly improved average gluteus medius strength, while average gluteus medius strength was not significantly difference between males and females in the experimental group. This suggests males and females benefit similarly from this ACL injury prevention program and the widespread use of this ACL injury prevention program may potentially decrease ACL injuries

Word Count: 339