The Use of an Anterior Cruciate Ligament Injury Prevention Education Program with Division III Collegiate Female Athletes

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Abstract

Eight NCAA Division III female collegiate athletes participated in a study pertaining to Anterior Cruciate Ligament (ACL) injury prevention education and student athletes. The purpose of this study was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention education program pertaining to ACL injuries and injury prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention. The data confirmed that there was an increase in ACL knowledge among the female athletes (participants) following the ACL injury prevention education program.
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Chapter 1: Introduction

As a certified athletic trainer, the researcher had observed more anterior cruciate ligament (ACL) injuries in female athletes than in male athletes. The researcher had also noticed that female athletes were not knowledgeable about ACL injury prevention. As a certified athletic trainer it was observed that ACL injuries can have a traumatic effect on a high school or collegiate athlete. An injury of this magnitude often meant loss of an entire season, scholarship funding, compromised academic performance, forms of depression, and possible future knee problems. Female athletes were more likely to experience ACL injuries for various reasons. According to Hewett & Myer (2005) female athletes have a 4-6 times higher incidence of ACL injury than their male counterparts. Therefore, a project was constructed to examine the effectiveness of a ACL injury prevention program in increasing the knowledge of female athletes, which may help prevent ACL injuries in the future for these female athletes in the training program.

Statement of Problem

The purpose of this project was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention program pertaining to the ACL injuries and injury prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention.

The research questions were:

1. What was an ACL and how were ACL injuries defined according to the professional literature reviewed?
2. According to the professional literature reviewed, what were the reasons female athletes were more likely to injure their ACL than male athletes?

3. What were the various components of an effective ACL injury prevention program according to the professional literature reviewed?

4. Was the female athletes’ knowledge of ACL injuries and ACL injury prevention increased after the ACL injury prevention education program?

Justification

This project was done as an effort to increase the knowledge of female athletes at the Division III level of ACL injury prevention. As a certified athletic trainer, it was observed that a female athlete was more likely to injure their ACL in comparison to a male athlete. Additionally, the researcher observed that typically female athletes were not trained in any special ways nor did they have any experience with ACL injury prevention programs. As a certified athletic trainer at a NCAA Division III school, the researcher conducted this project in order to decrease injuries, which was one of the main jobs of a certified athletic trainer at any level. This project was also designed as a method for female athletes to increase their knowledge of ACL injury prevention. Lastly, the results of this project might have provided these female athletes with a training protocol that they can follow to not only increase their knowledge, but perhaps reduce ACL injuries as well.

Definition of Terms

Anterior Cruciate Ligament (ACL) –

1) a cruciate ligament of each knee that is attached in front to the more medial aspect of the tibia, that passes upward, backward, and laterally through the middle of the knee crossing
the posterior cruciate ligament to attach to the femur, that functions to prevent hyperextension of the knee and to keep the tibia from sliding forward in relation to the femur, and that is subject to sports injury especially by tearing (Merriam-Webster, 2007)

NCAA Division III athletics –

1) The National Collegiate Athletic Association states that opposed to Division I and II athletics, where student-athletes receive scholarships and the spectator of the contests are of primary concern:

Division III institutions have to sponsor at least five sports for men and five for women, with two team sports for each gender, and each playing season represented by each gender. There are minimum contest and participant minimums for each sport. Division III athletics features student-athletes who receive no financial aid related to their athletic ability and athletic departments are staffed and funded like any other department in the university. Division III athletics departments place special importance on the impact of athletics on the participants rather than on the spectators. The student-athlete's experience is of paramount concern. Division III athletics encourages participation by maximizing the number and variety of athletics opportunities available to students, placing primary emphasis on regional in-season and conference competition (NCAA, 2007)

Limitations and Appropriate Use of Results

There were limitations pertaining to this project. One limitation was that the ACL injury prevention training program took place at a small Division III college. Due to the small number of students enrolled at the college, the researcher had a limited number of female athletes to participate in the training program. In addition, the time permitted to collect the data for the project was limited. The short period of time to complete the ACL injury prevention training program could have affected the outcome of the project. Due to these limitations, the results of this project may not be generalized to other populations.
Chapter 2: Review of Literature

The purpose of this project was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention program pertaining to ACL injuries and injury prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention.

The research questions were:

1. What was an ACL and how were ACL injuries defined according to the professional literature reviewed?
2. According to the professional literature reviewed, what were the reasons female athletes were more likely to injure their ACL than male athletes?
3. What were the various components of an effective ACL injury prevention program according to the professional literature reviewed?
4. Was the female athletes’ knowledge of ACL injuries and ACL injury prevention increased after the ACL injury prevention education program?

Research Question #1: What was an ACL and how were ACL injuries defined according to the professional literature reviewed?

In order to answer research question #1, a review of literature was conducted. Hensch (2007) stated that out of the four main ligaments in the knee, the ACL has been identified as one of the main ligaments of the knee. Hensch indicated that the ACL was connected to the tibia (shinbone) and ran up to the femur (thighbone) where it connected the two bones together. Starkey and Ryan (2002) stated that the primary purpose of the ACL was to keep the shinbone from sliding excessively forward or anterior on the thighbone. The ACL also provided an overall
stability, especially with internal rotation of tibia on the femur, external rotation of tibia on the femur, and hyperextension of the knee joint (Starkey and Ryan).

Starkey and Ryan (2002); and Hensch (2007) stated that the mechanism or how an ACL became injured was either from non-contact or contact. According to Hensch, more than 75% of ACL injuries were non-contact. A non-contact ACL injury could have happened with the foot being planted with rotation of the lower leg or a sudden stop with a quick direction change while running, cutting, pivoting, or landing from a jump (Starkey and Ryan). Starkey and Ryan defined a contact ACL injury as that, entailed a direct force produced by a fall or a hit, perhaps to the side of the knee or the front causing hyperextension.

According to the professional literature reviewed, the ACL was defined as one of the four main ligaments in the knee (Hensch, 2007). Contact and non-contact were the two ways described how an ACL became injured according to the professional literature reviewed (Starkey and Ryan 2002; and Hensch). In addition, it was considered an injury prevalent with female athletes.

Research Question #2: According to the professional literature reviewed, what were the reasons female athletes were more likely to injure their ACL than male athletes?

In order to answer research question #2, a review of literature was conducted. Various risk factors that predisposed females to ACL injuries were body types (wider hips), hormonal differences (menstrual cycle), upright body position, and neuromuscular control imbalances (Hensch, 2007). Griffin et al. (2000) stated, “gender differences in neuromuscular control are believed to be the most important reason for the disproportionate rate of ACL injury” (p. 142). According to Myer, Ford, and Hewett (2004) during puberty females have an absence or falling
behind of adapting in a neuromuscular way like the males do during puberty, in turn this has lead to females increased imbalances compared to males. Myer et al. (2004) examined three specific neuromuscular control imbalances seen in female athletes, which were ligament dominance, quadriceps dominance, and leg dominance.

Ligament dominance was the first imbalance to be discussed. This imbalance occurred when the athlete would allow their knee ligaments to absorb a significant portion of the ground reaction force rather than allowing their lower extremity musculature to absorb the forces during maneuvers (Myer et al., 2004). The result was valgus knee movements or knock kneed position, especially during single leg standing, pivoting, or decelerating (Myer et al.; Fischer, 2006). Myer et al. stated that the lack of muscle control and knee stability as seen in this imbalance of ligament dominance in females lead to increased load and stress on the knee ligaments.

The second neuromuscular imbalance examined was quadriceps dominance. Myer et al. (2004) explained, “Quadriceps dominance is an imbalance between the quadriceps and hamstring recruitment patterns” (p. 219). Females tended to land more erect with legs extended, so they were using their knee extensors over knee flexors to control knee stability during high torque force movements (Hensch 2007; Fischer, 2006). With minimal knee flexion upon landing, cutting, or pivoting this increased the pull of the tibia anteriorly, which stressed the ACL (Myer et al.; Fischer). Deep knee flexion with the hamstrings used instead of quadriceps had a pull of posterior on the tibia, which placed less stress on the ACL (Myer et al.; Fischer). Myer et al. explained that there was just too much dependence on the quadriceps muscles, which may lead to imbalances in strength and coordination between the quadriceps muscles and knee flexor musculature, which was a problem. Cutting and landing with low or minimal knee flexion angles
in females who had quadriceps dominance predisposed themselves to ACL injuries (Myer et al.; Fischer).

Leg dominance was the last neuromuscular imbalance discussed. Hewett, Myer, and Ford (2001) described leg dominance as, “the imbalance between muscular strength and coordination on opposite limbs, with the dominant limb often demonstrating greater strength and coordination” (p. 220). When compared side to side, the differences in neuromuscular strength and coordination have been shown to have an effect on the increase of injury (Myer et al. 2004; Myer, Ford, Palumbo, and Hewett 2005). The dependence on the dominant leg can put greater stress on that knee, while the non-dominant limb was at risk because the musculature cannot withstand the high forces since it was weaker (Myer et al.).

According to the professional literature reviewed, there were several reasons that female athletes had a higher occurrence of ACL injuries. The major reasons were three neuromuscular control imbalances seen in female athletes that predispose them to ACL injuries. The imbalances were ligament dominance, quadriceps dominance, and leg dominance.

*Research Question #3: What were the various components of an effective ACL injury prevention program according to the professional literature reviewed?*

In order to answer research question #3, a review of literature was conducted. It was determined that ACL prevention programs should include various exercises in order to prevent and help neuromuscular control imbalances. Hensch (2007) stated that well rounded programs included muscular strength, balance, and sports related movements. Hewett, Lindenfield, Riccobene, and Noyes (1999) stated that neuromuscular training helped to train the musculature that stabilized the knee joint, which in turn may help decrease injury in the knees of females.
Neuromuscular training was described as exposing the athlete to movement patterns that generated greater dynamic knee control through various plyometric exercises, movement training, and strength training (Fischer, 2006). In addition Fischer (2006) believed this training was beneficial to any athlete involved with sports that have cutting, jumping, landing, and decelerating forces, but it was especially important for females who had certain neuromuscular control imbalances. The training was used to correct imbalances in females that could have led to ACL injuries.

Some of the concepts in neuromuscular training were the strength training, plyometric exercise, and movement training, which were key for female athletes. Strength training was important to incorporate into training because females show decreased baselines of strength training compared to males (Myer et al., 2005). Female athletes have shown different strength imbalances that left them open for more injury. Lehnhard R., Lehnhard H., Young, and Butterfield (1996) explained that muscles with greater strength and joints with greater stability are less likely to become injured.

The plyometric and movement training were similar concepts as far as the positions the athlete should stay in for their sport and being aware of their landing techniques. With plyometric training the landing techniques were the focus. The movement training was working with the females when they were cutting and decelerating. To safely introduce the athletes to movement training, double leg exercises were used first. As the training continued more single leg movements were introduced, but the focus was on correct landing techniques. While the athlete was put through plyometric training, they were instructed to stay in a functionally stable position, which was with knees comfortably flexed, shoulders back, eyes up, feet about shoulder width apart, and body mass balanced over balls of the feet (Myer et al., 2005).
Various neuromuscular training programs have been proven to decrease possible dangerous landing forces in females (Myer et al. 2005; Fischer 2006; Myer et al. 2004). These training programs were centered on trying to teach proper landing and moving techniques, through plyometric work and strength training to fix various imbalances that were presented in females (Myer et al., 2004). Hewett et al. (2001) stated that, “neuromuscular training results in significant decrease of 50% in valgus and varus movements at the knee and peak impact force decreases of 80% of mean body weight in female athletes when landing from a jump” (p. 219).

Three prevention programs were examined in this section. Clearly, the purpose of these prevention programs was to reduce the ACL injuries in their female athletes. The implementation of these prevention programs provided evidence that an ACL prevention program could be beneficial in prevention of ACL injuries in female athletes (Hewett et al., 1999; Mandelbaum, Silvers, Watanabe, Knarr, Thomas, Griffin, Kirkendall, and Garrett, 2005; Myklebust, Engebretsen, Braekken, Skjolberg, Olsen, and Bahr, 2003).

Hewett et al. (1999) conducted a neuromuscular training study. In his study, he used an untrained group of females, trained group of females, and a control group of males. The untrained group had a higher incidence of knee injury than the control group, but there was no significant difference between the trained and control group. Female injury rates went from 0.43 to 0.12 over a 6-week program. The untrained group had an injury rate 3.6 times higher than the trained group and 4.8 times higher than the male control group. The trained females showed a decrease in injuries following the program.

Mandelbaum et al. (2005) developed a neuromuscular training program that was a two-year follow up study that looked at whether the incidence of ACL injuries would decrease. The
first year there was a female control group and a female trained group. The second year there was also a control and trained group. In year one, there were two ACL tears in the trained group and 32 in the control group. In year two, there were four ACL tears in the trained group and 35 in the control group. There was an overall 88% reduction in non-contact ACL injury in year one and 74% reduction in year two.

Myklebust et al. (2003) designed a study of ACL prevention program that was done over a three season period, in which they wanted to assess the effect of neuromuscular training program in the incidence of ACL injuries in female team handball players. The subjects were female team handball players at the Division I-III levels in Norway. The first season was a control season, which used 942 players. The second and third seasons were the intervention seasons, using 855 and 850 players. There were 29 ACL injuries during the control season, 23 during the first intervention season, and 17 during the second intervention. In the elite division, there were 13 injuries during control season, 6 during the first intervention, and 5 during the second. There was an overall reduction in the ACL injury, especially among the elite division who completed the ACL injury prevention program compared with those who did not.

When compared the three neuromuscular training programs had more similarities than differences. All three studies had provided an educational videotape for the athletes and coaches to watch, which entailed things such as jump training, landing techniques, strength training, warm-up activities, and stretching Hewett et al., 1999; Mandelbaum et al. 2005; Myklebust et al. 2003). A common component of the studies was that all three studies had similar effects with the prevention and lowering of injuries to the knees, especially the ACL.
Hewett et al. (1999) described a program that provided more detail with different progressive phases for the athlete. The first phase was the technique phase, the second was the fundamentals phase, and the final phase was performance. There was a difference in how the studies were run. The first program that was examined lasted 6 weeks and was a preseason program (Hewett et al.). The Mandelbaum et al. (2005) study was a two-year follow up with different groups both years. The Myklebust et al. (2003) study was an intervention study over three seasons long, each lasting 5-7 weeks.

It was stated, in the professional literature that effective ACL injury prevention programs should have various components to help reduce the risk of injury for female athletes. Balance, strength, and sports related movements were important factors when developing prevention programs. The three studies that were examined, worked with balance, strength, and landing techniques at some point in order to prevent ACL injuries.

Conclusion

A review of literature was conducted to answer questions 1, 2, and 3. The ACL was described as one of the four main ligaments in the knee. Females were more likely to injure their ACL in comparison to their male counterpart. Researchers had identified various reasons why females were more predisposed to injuring their ACL’s more than males, which were body types, hormonal differences, and neuromuscular control imbalances (Hensch, 2007). There were three neuromuscular imbalances seen in females that contributed to the ACL injuries, which were ligament dominance, leg dominance, and quadriceps dominance. Lastly, the professional literature reviewed identified what comprises an effective ACL injury prevention program. Hensch (2007) stated that well rounded programs included muscular strength, balance, and sports
related movements. Three ACL injury prevention studies, specific to female athletes, provided evidence that ACL prevention programs could be beneficial in prevention of ACL injuries in female athletes (Hewett et al., 1999; Mandelbaum et al., 2005; Myklebust et al., 2003).
Chapter III: Methods and Procedures

The purpose of this project was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention program pertaining to ACL injuries and injury prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention.

The research questions were:

5. What was an ACL and how were ACL injuries defined according to the professional literature reviewed?

6. According to the professional literature reviewed, what were the reasons female athletes were more likely to injure their ACL than male athletes?

7. What were the various components of an effective ACL injury prevention program according to the professional literature reviewed?

8. Was the female athletes’ knowledge of ACL injuries and ACL injury prevention increased after the ACL injury prevention education program?

To answer research question #4, the knowledge of the female athletes was assessed by a pre- and post-test, which was administered both prior to and following the athlete ACL injury prevention education program. The scores of the pre- and post-tests were calculated and analyzed.

Eight female collegiate athletes participated in the study, three were volleyball players, four were soccer players, and one was a softball player. The head soccer, volleyball, and softball coaches along with athletic director at the college granted permission to the researcher to conduct this study. A consent form, (see Appendix A for the consent form) survey, (see Appendix B for
the survey) and pre-test (see Appendix C for the pre/post-test) were completed by each participant at the beginning of the program.

The training program consisted of three areas of focus pertaining to the ACL injury and ACL injury prevention. Videos, various pictures, and a knee model, which all directly related to the three areas of focus, were used as instructional supports and were discussed with the participants. At the conclusion of the program, the post-test was administered to the participants. The differences between the pre- and post-tests were used to determine whether or not there was an increase in knowledge from the ACL injury prevention education program. An Excel spreadsheet and bar graph showed the data gathered from the pre- and post-tests.

Participants

Eight collegiate female athletes from a small, National Collegiate Athletic Association Division III college, located in the Midwest, participated in this study. There were four soccer players, three volleyball players, and one softball player. All eight of the participants were freshman students at the college. None of the athletes had participated in an ACL injury prevention training program. Three of the eight athletes’ undergraduate major was athletic training.

Intervention

An ACL injury prevention education program was designed for female collegiate athletes. The information that was used in the program was gathered from various, up to date original research articles on ACL injury prevention programs, sports medicine text books, and secondary sources. The researcher decided to focus on three areas within the topic of the ACL, which were the anatomy of the ACL and ACL injuries, gender differences, and the components of ACL injury prevention programs. The three topics of the ACL and ACL injuries, gender
differences, and components of ACL injury prevention programs, were essential and relevant when putting together an ACL injury prevention education program for female athletes.

The first topic discussed was the ACL and the mechanism of injury. The participants needed a basic understanding of the anatomy of the ACL and how it was injured in order to proceed through the program. The ACL was broken down into its full name, anterior cruciate ligament, and each word was defined. The primary purpose of the ACL and its location in the knee was discussed. A model of the knee and pictures were used to aid in the understanding of where the ACL is located and its purposes during the first topic of discussion.

The mechanism or how the ACL was injured was addressed as well in the first topic. The point of emphasis was the importance of the two ways in which the ACL could become injured, which were through non contact or contact. The importance of why more ACL injuries are non-contact was discussed as well. For the participants to understand what non contact and contact ACL injuries were, there were two pictures used in the presentation.

For the participants to better understand the ACL injury and the different ways it might occur, five videos from You Tube that illustrated athletes injuring their ACL’s were utilized. The first video went into detail about the athlete’s injury and why it might have happened. This was an important example for the participants to see for two reasons. The first reason was that it was a female athlete who suffered the ACL injury and the second reason was the mechanism was non-contact. The second video was very short, but was another example of a non-contact ACL injury. Both You Tube videos three and four were of females injuring their ACL’s through the non contact mechanism as well. The fifth video was an example of a contact ACL injury; it showed the athlete getting his knee pushed backwards, into hyperextension. These videos were
beneficial to the participants because it allowed for a visual example of how an ACL was injured and the difference between the non contact and contact mechanism.

Next, the researcher introduced the topic of gender differences. It was established in Chapter I that females endure more ACL injuries than their male counterparts. This topic focused on what those risk factors might be that predisposed female athletes to ACL injuries. The participants learned that their body types, with wider hips and smaller knees and landing in a more erect position placed more stress on the knees. Also, hormonal differences perhaps played a part in female ACL injuries due to the various hormones during the menstrual cycle that might make their ligaments prone to injury. But the main focus of this topic was the neuromuscular control imbalances.

It was discussed that there were three different neuromuscular control imbalances, which were ligament dominance, quadriceps dominance, and leg dominance. Each imbalance was explained separately to the participants in a way that they were able to comprehend the information. The participants also learned in this section that these imbalances could be corrected through specific neuromuscular training.

Following the discussion of gender differences, the final topic of ACL injury prevention programs and the components of the programs were introduced. After the researcher reviewed journal articles and found up to date ACL injury prevention programs, the researcher applied that information to the ACL injury prevention education program. The emphasis of the ACL injury prevention programs and components topic was to determine what made up effective ACL injury prevention programs for female athletes, it was then explained with the participants in a way they could comprehend the information. The ACL injury prevention programs were described in more
detail and specifically called neuromuscular training programs. Neuromuscular training programs were defined as training in which exposed the female athlete to movement patterns to help generate better dynamic knee control. It was also discussed that specific neuromuscular training programs would help reduce and eliminate any of the three imbalances, which were ligament, leg, and quadriceps dominance, in turn preventing ACL injuries.

The researcher explained that the ACL injury prevention programs should entail a wide variety of specific exercises in order to be beneficial to a female athlete. It was discussed that the prevention training should include strength training, balance exercises, agility, plyometrics, and movement training. The different exercises were explained to the participants and examples were shown in the power point. Landing techniques and a good athletic stance were emphasized and key points were discussed of each in order to prepare the participants for the in class activities.

The researcher described landing techniques as one of the most important lessons in ACL injury prevention training. The key points for good landing techniques were soft, controlled landings and being in a bent knee position. It was also noted that even though plyometrics were used, plyometrics in this situation were not used to increase power and strength but, instead the focus was on correct and safe landings. The importance of a good athletic stance at all times, especially during all athletic movements such as landings and cutting was established by the researcher. The participants learned that a good athletic stance entailed the knees being comfortably flexed, shoulders back, eyes up, feet shoulder width apart, and body mass balanced over balls of the feet.

Once the three topics were presented and discussed, the researcher had two activities planned for the participants to complete. The first activity for the final portion of the ACL injury
A prevention education program was having the participants demonstrate a proper athletic stance. The researcher had the female athletes stand up and perform their best athletic stance. The participants who played volleyball had the best athletic stance; because of their usual ready position on the court were bent knees, eyes up, and on the balls of their feet. The researcher instructed each participant on how to make their athletic stance better and stressed to them the importance of a quality stance throughout any athletic movement. Once the researcher felt that the participants had mastered a good athletic stance, the second activity was introduced.

The second activity was a box jump landing. The researcher used a small plyometrics box to support the learning. This activity was important because it emphasized not only the soft landings, but also the necessity of having the female athletes assume the appropriate athletic stance at the landing. This activity was used in ACL injury prevention programs to help train the muscles around the knee and reduce the stress on the knee. Only six of the eight female athletes participated in this activity; the other two were unable due to a previous back and knee injury. Each participant stepped up on top of the box one at a time and on my command jumped down from the box. Their landing was evaluated by the researcher to make sure they had a soft landing, bent knees, on the balls of their feet, shoulders up, eyes up, and knees in alignment with feet. Each participant practiced the exercise several times. By the end of the activity the participants understood and were able to execute an appropriate landing.

**Instruments**

A pre- and post-test was used to determine if the knowledge of the participants was increased through participation in the ACL injury prevention education program. The pre- and post-test had 25 questions each, covering the three topics addressed in the ACL injury prevention program. Each question was a statement related to ACL's and ACL injury prevention
that were either true or false. Each answer was worth two points; therefore, the total possible points for the questionnaires were 50. The same test was used at the beginning and end of the ACL injury prevention education program. Each participant drew a number one through eight; whichever number they picked, they were instructed to write that number on top of their pre- and post-tests.

A survey was also used by the researcher in order to gain some background knowledge of the participants. The researcher wanted to know if any of the participants had injured their ACL's before or had classes about ACL injury prevention before. They were also asked their major at Defiance College.

Procedures

Permission was granted from the volleyball coach, softball coach, soccer coach, and the athletic director at the college to proceed with the ACL injury prevention education program for female athletes. The participants in the study were volleyball players, soccer players, and one softball player. These female collegiate athletes were asked to participate in this project. Once eight of the female athletes had agreed, a date and time for the education program to take place was set by the researcher. On the day of the education program the participants were given a packet, which included instructions, a consent form, survey, and the pre- and post test. After they signed the consent form and filled out the pre survey, the participants were instructed to set those papers aside. The participants then wrote their numbers they had drawn onto their pre- and post-tests.

Once the pre-tests were completed, the researcher collected them and started the ACL injury prevention education program. The training consisted of an introduction, a discussion of the three topics, specific ACL injury videos, various pictures and models, followed by the
activities. The ACL injury prevention education program was conducted in an informal way in order to make the participants feel like they were able to ask questions and discuss the topics openly.

Immediately following the program the participants were asked to complete the post-tests. Upon completion of the post-test, they were permitted to leave the room.

Timeline

During the months of September and October, the researcher reviewed journal articles pertaining to ACL injury prevention. The research articles focused on gender differences and ACL injury prevention programs. The researcher was interested in finding information and research on neuromuscular imbalances, anatomy of the ACL, mechanism of injury, and components of ACL injury prevention programs. The goal of the researcher was to find information to put together a basic ACL injury prevention education program for female athletes.

In November, the importance of female athletes’ understanding ACL injuries and ACL injury prevention was established by the researcher through a review of the professional literature. The researcher focused on exact ways to implement a program of that manner in the month to come.

In December, the researcher began to construct the outline of the education program. Also, the researcher asked for participants for the study. One softball player, four soccer players, and three volleyball players were asked to be involved and all were freshman at Defiance College. The researcher further developed different ideas for the implementation of the ACL injury prevention education program. Also in the month of December the researcher developed
the pre- and post- test and survey. The survey was to gain background knowledge on the participants.

In the beginning of January the researcher completed the education program and also developed a PowerPoint presentation to help aid in the learning process (see Appendix D for the PowerPoint). The PowerPoint was aligned with what the professional literature considered best practices in ACL injury prevention. The ACL injury prevention education program took place January 14, 2008.

Data Analysis

The data used for this project were the scores from the pre- test and post- test. An Excel spreadsheet was designed to organize and analyze the data from the pre- and post- tests scores. A bar graph was used to show the difference between the two scores from the pre- and post- tests.

There were 25 questions on the pre- and post- test; each question was worth two points, which made the pre- and post- tests worth a total of fifty possible points. A spreadsheet with the columns headed Participant #, Pre- Test Scores, Post- Test Scores, and Difference was designed by the researcher.

The post- test scores were subtracted from the pre- test scores to get the difference; the scores from this calculation were put into the Difference column. A positive number in the difference column would illustrate that more questions were answered correctly on the post-questionnaire than on the pre-questionnaire.

To compare the results of the pre- and post- tests for each participant a bar graph was created. Each column had a different color to represent the categories. Purple represented the
pre-test scores and yellow represented the post-test scores. The black bar showed the difference between the two.

Conclusion

In order to answer research question #4, methods and instruments were designed to collect data to determine if participant knowledge of ACL’s and ACL injury prevention increased. Eight female collegiate athletes participated in the study. An ACL injury prevention education program was designed and implemented focusing on three main topics— which were ACL and ACL injury, gender differences, and the components of ACL injury prevention programs. A pre- and post-test was used to measure the participants’ knowledge before and after the program.

The review of professional literature for the study began in September and continued through mid November. At the end of November and through the beginning of January, the details of the education program were finalized. The ACL injury prevention education program was conducted on January 14, 2008. At that time, all the data was collected and the data was analyzed. A spreadsheet consisting of the scores from the pre- and post-test was created, and a bar graph was developed to compare the scores.
Chapter IV: Results

The purpose of this project was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention program pertaining to ACL injuries and injury prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention.

The research questions were:

9. What was an ACL and how were ACL injuries defined according to the professional literature reviewed?

10. According to the professional literature reviewed, what were the reasons female athletes were more likely to injure their ACL than male athletes?

11. What were the various components of an effective ACL injury prevention program according to the professional literature reviewed?

12. Was the female athletes' knowledge of ACL injuries and ACL injury prevention increased after the ACL injury prevention education program?

A pre- and post- test was administered to the six participants of the study. The total scores out of 50 points from the ACL injury prevention knowledge pre- and post- tests were the data for this project. The participant scores from the pre- tests were: 28 points for Participant #1 and Participant #4. Participants #3 and #8 totaled 26 points. Participant #2 scored 34 points. Participant #6 received 32 points. Participant #7 had a score of 24 points. Participant #5 scored 44 points.
The post-tests scores were: Participants #3, #4, #7, and #8 scored 40 points. Participants #2 and #5 received 46 points. Participant #1 had a score of 44 points. Participant #6 scored 42 points.

After the pre- and post-tests were scored, the differences between the tests were determined. The difference was calculated by taking the post-test scores and subtracting the pre-test scored. The differences for each of the participants were: Participants #1 and #7 had a difference of +16. Participants #2 and #4 had a difference of +12. Participants #3 and #8 had a difference of +14. Participant #5 had a difference of +2. Participant #6 had a difference of +10.

The scores from the ACL injury prevention pre- and post-tests and the differences between the two scores are shown in Figure 1. The participant scores and the differences were shown through a bar graph in Figure 2. A positive number in the difference column indicated that the post-test had more correct answers than the pre-test.

<table>
<thead>
<tr>
<th>Participant #</th>
<th>Pre-Test Scores</th>
<th>Post-Test Scores</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>44</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
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<td>16</td>
</tr>
<tr>
<td>8</td>
<td>26</td>
<td>40</td>
<td>14</td>
</tr>
</tbody>
</table>

*Figure 1. ACL Injury Prevention Knowledge Pre- and Post- Test Table: Results and the differences between the scores.*

The data indicated that one hundred percent of the participants scored higher on the post-test than they did on the pre-test.
Figure 2. ACL Injury Prevention Knowledge Pre- and Post- Test Bar Graph:

Results and the Differences between the scores.

The data showed that all of the participants had an increase in ACL injury prevention knowledge following the ACL injury prevention education program. The researcher established that all of the female athletes scored more points on the post-test than they did on the pre-test.

Summary

The scores were collected from the pre- and post-tests and the researcher created a table and a bar graph to represent the data. After collecting the data, the researcher discovered that all of the participants scored higher on the post-test than they did on the pre-test.
Chapter V: Discussion

The purpose of this project was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention program pertaining to ACL injuries and injury prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention.

The research questions were:

13. What was an ACL and how were ACL injuries defined according to the professional literature reviewed?
14. According to the professional literature reviewed, what were the reasons female athletes were more likely to injure their ACL than male athletes?
15. What were the various components of an effective ACL injury prevention program according to the professional literature reviewed?
16. Was the female athletes’ knowledge of ACL injuries and ACL injury prevention increased after the ACL injury prevention education program?

Meaning of Findings

All eight of the participants scored higher on the post-test than on the pre-test following the ACL injury prevention education program. The increase in the scores indicated that exposure to an ACL and ACL injury prevention education program might have increased the knowledge of ACL injury prevention in the female participants.

Summary

The purpose of this project was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention program pertaining to ACL injuries and injury
prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention.

Eight female collegiate athletes from a small, National Collegiate Athletic Association (NCAA) Division III, located in the Midwest, participated in this study. Three of the athletes were volleyball players, four were soccer players, and one was a softball player. The head soccer, volleyball, and softball coaches along with athletic director at the college granted permission to the researcher to conduct this study. Instructions, a consent form, a survey, and pre-test were completed by each participant at the beginning of the program. Each participant drew a number and was instructed to place the number on their pre- and post-tests.

Once the pre-tests were completed, the researcher collected them and started the ACL injury prevention education program. An ACL injury prevention education program was designed for female collegiate athletes. The information that was used in the program was gathered from various, up to date original research articles on ACL injury prevention programs, sports medicine text books, and secondary sources. The researcher decided to focus on three areas within the topic of the ACL, which were the anatomy of the ACL and ACL injuries, gender differences, and the components of ACL injury prevention programs. The training consisted of an introduction, a discussion of the three topics, specific ACL injury videos, various pictures and models, followed by the specific activities to help the participants understanding of ACL injury prevention. The program ended with the researcher encouraging the participants to ask questions and engage in conversation relevant to the topics.

Immediately following the program the participants were asked to complete the post-tests. The researcher scored the pre- and post-tests and began the data analysis after the
completion of the post-tests. A table and a bar graph were used to show the scores from the pre- and post-tests and the differences between the two. All eight of the participants experienced higher scores on the post-test than on the pre-test, which indicated increase knowledge about ACL and ACL injury prevention.

**Recommendations**

The researcher identified several recommendations for future studies. These recommendations were implementing the study at a Division I or Division II level, using more athletes in the study, and lengthening the ACL injury prevention program.

The first recommendation was to implement this study at a larger college, instead of an NCAA Division III institution. The results might be different when working with female athletes at the Division I and II levels. There might not have been an increase in knowledge with the Division I and II athletes, because of the different demands and requirements to their sport as compared to Division III athletes. At the Division III level, the athletes were more student-athletes than athlete-students meaning that, they do not receive athletic scholarship money, nor was their training as intense as the Division I and II levels. It would be interesting to conduct the ACL injury prevention education program at the higher levels to see what the outcomes might be, and to determine difference between the participants at the different levels.

The next recommendation was to use more participants instead of just eight. By using only eight participants, the researcher had limited data to analyze. A suggestion for further research would be to increase the number of participants. By using more participants, the researcher might collect a more wide range of data and perhaps more accurate results to analyze.
Lastly, the researcher recommended implementing a longer ACL injury prevention education program. The amount of information required for such a program probably necessitates a longer period of instructional time. By expanding the program to three or four weeks, with more sessions in between perhaps would have benefited the participants. The participants of this study could have received more information regarding ACL injury prevention, if the program was longer, which would directly have a positive effect on the participants.

A recommendation was also identified for further research on the ACL injury prevention programs. This recommendation would involve implementing an actual training program for female athletes focused on injury prevention.

The use of the ACL injury prevention education program in connection with an actual training program for the female athletes could not only lead to a better understanding of the injury and prevention, but perhaps less ACL injuries to the female athletes. Previous studies used in Chapter 2 explored various ACL prevention training programs, proving that female athletes put through training decreased ACL injuries.

Conclusion

The purpose of this project was to determine if the implementation of an Anterior Cruciate Ligament (ACL) injury prevention program pertaining to ACL injuries and injury prevention for female athletes at a NCAA Division III college would increase their knowledge of ACL injuries and prevention. A pre-test was developed and female collegiate athletes from various teams participated in an ACL injury prevention education program to establish if their knowledge of ACL, ACL injuries, and ACL injury prevention was increased. The scores from
the pre- and post- tests were used to determine the difference, to ascertain whether or not knowledge was gained from the education program. After analyzing the data, it was established that all of the participants increased their knowledge on ACL injury prevention.
References


Appendix A

Consent Form

An ACL Injury Prevention Education Program for Female Collegiate Athletes

I, .........................................................., have been invited to participate in the above study, which is being conducted under the direction of Carrie Wagner. My agreement is based on the understanding that the research study will first test my knowledge on ACL injuries and prevention. An education program will then take place focusing on three areas related to the ACL and prevention, followed immediately by a post-test to assess any knowledge gained from the education program. I consent to the use and publishing of results from this study provided my identity is not revealed. I voluntarily consent and offer to take part in this study.

Signature (Participant): __________________________________________

Date: ___________________________ Time: ___________________________

Participant’s Contact Telephone No. ___________________________________
Appendix B

Background Survey for the Female Participants

What is your age? ____________________________

What is your education class?

☐ Freshman
☐ Sophomore
☐ Junior
☐ Senior

What is your undergraduate major: ____________________________

What collegiate sport do you participate in? ____________________________

Have you injured your ACL before? ____________________________

If the above question was yes, how did you injure it? ____________________________

Have you ever been through ACL injury prevention training before? _____________

Would ACL injury prevention training be something you would like to participate in? _____
Appendix C

**Pre/Post Test**

The ACL and ACL Injury Prevention Knowledge Pre/Post Test

1. Female athletes have a greater risk of tearing their ACL’s then male athletes.  

   T  F

2. An ACL injury is devastating to an athlete, but the athlete is able to bounce back in a matter of 3 months from the injury.  

   T  F

3. ACL stands for the anterior carpal ligament.  

   T  F

4. The ACL is located in the knee and hip.  

   T  F

5. The ACL connects the shin bone and thigh bone together.  

   T  F

6. The primary purpose of the ACL is to keep the tibia from sliding forward on the femur.  

   T  F

7. The ways in which the ACL can become injured is through non-contact and contact.  

   T  F

8. Most ACL injuries are from contact, an example would be a football player getting his knee driven backwards (hyper extended) by another player.  

   T  F

9. Having the foot planted with rotation of the lower leg or a sudden stop with a quick direction change would be examples of a non contact.  

   T  F

10. Some risk factors that predispose females to ACL injuries are large quantities of muscle mass, hormonal differences, a stable athletic stance, and neuromuscular control imbalances.  

    T  F

11. The gender differences in neuromuscular control seem to be an important factor for why females tear their ACL’s more than males.  

    T  F

12. The three neuromuscular control imbalances are ligament dominance, leg dominance, and quadriceps dominance.  

    T  F

13. Ligament dominance means that the athlete uses their ligament to jump and land more than what they should.  

    T  F

14. Leg dominance means that the athlete shows a greater strength and coordination in their dominate leg than in the opposing one.  

    T  F

15. Quadriceps dominance is an imbalance between the quadriceps and hamstring recruitment patterns.  

    T  F

16. ACL prevention programs do not need to include various exercises in order to prevent and help neuromuscular control imbalances.  

    T  F
17. Neuromuscular training is important to help train the musculature that stabilizes the knee joint. T F
18. Strength training, agility, balance, and sports related movements are all included in prevention programs. T F
19. In plyometric training for ACL injury prevention, the technique in which how the athlete jumps up is more important than how they land. T F
20. Working with the females while they were cutting and decelerating is called movement training. T F
21. Single leg movements and landings should be done gradually throughout the program for safety. T F
22. A functionally stable position is important to use during athletic movements and plays a big part in the ACL prevention program. T F
23. The functionally stable position is having the knees comfortably flexed, shoulders back, eyes up, feet together, and body mass leaning more to one side than the other. T F
24. Females are about equal to males when it comes to overall strength. T F
25. Neuromuscular training for females has been proven to help decrease and/or prevent major injuries to the ACL. T F
Appendix D

The ACL and ACL Injury Prevention Education Program Power Point

Test and Answers

Mission
- To increase knowledge of ACL injury and prevention with female athletes

Itinerary
- Pre-test
- Address 3 topics
- In class activities
- Answer questions
- Post-test
Please take this time to read the instructions, fill out the consent form, fill out survey, and take the pre-test.

Areas of Focus

• The ACL/mechanism of injury
• Gender differences
• ACL prevention programs
Background

- Hewett, Ford, & Myer (2004) identified that female athletes have a 4-6 times higher incidence of anterior cruciate ligament injury than their male counterparts.
- Efforts to decrease ACL injuries in young female athletes is done through specific intervention and training programs. EX. Neuromuscular programs
- It is important to know and understand why and how females injure ACL's more.
- An ACL injury can have traumatic effect on athlete
- Loss of season, scholarship, compromised academic performance, forms or depression, future problems with knees

The ACL and Mechanism of Injury

- Anterior?
- Cruciate?
- Ligament?
- Location?
- Purpose?
- Season ending injury...sometimes career
- Surgery to have a fully functioning knee joint
- Rehab
- Mechanism (how)
  - contact or non contact (75% non contact)
  - non contact, foot planted in combination with lower leg rotation
  OR a sudden stop with a quick direction change while running, cutting, pivoting, or landing
  - contact, direct force produced by a fall or hit
Gender Differences

- It has been established more females tear their ACL's in comparison to males....but why?
- Multiple risk factors that predispose females to ACL injuries and not males
- Body types – wide hips, smaller knees
- Hormonal differences- menstrual cycle
- Neuromuscular control imbalances
  - According to Griffin et al. (2000) the gender differences in neuromuscular control are believed to be the most important reason for the disproportionate rate of ACL injury

What *can* change and what *cannot* change????
Gender Differences (Cont.)

- According to Lephart & Riemann (2001), neuromuscular control is the unconscious activation of muscles crossing the knee joint in response to sensory stimuli.

- According to Myer, Ford, & Hewett (2004), during puberty, females have an absence or falling behind of adapting in a neuromuscular way like the males do during puberty. In turn, this leads to females' increase of imbalances compared to males.

Gender Differences (Cont.)

- Myer et al. (2004) examined three specific neuromuscular control imbalances seen in female athletes, which were ligament dominance, quadriceps dominance, and leg dominance.

- Ligament dominance - occurs when rather allowing the lower extremity musculature to absorb the ground reaction force (shock) during maneuvers, the athlete lets the knee ligaments.

- Quadriceps dominance - imbalance between the quads and hamstring recruitment patterns.

- Leg dominance - According to Hewett, Myer, & Ford (2001), this is the imbalance between muscular strength and coordination in the opposite limb.
ACL Prevention Programs

- ACL prevention entails many exercises
- Neuromuscular training—exposing athlete to movement patterns
- These help to generate greater dynamic knee control
- Plyometrics, movement training, strength training, balance
- Specific studies done on ACL prevention


ACL Prevention Programs (Cont.)
ACL Prevention Programs

Bad Box Jump - upright, valgus alignment

Good Box Jump - good athletic stance

In-Class Activities

- Good Athletic Stance
  - knees comfortably flexed
  - shoulders back
  - eyes up
  - feet shoulder width apart
  - body mass balanced over balls of feet
  - Focus on good athletic stance throughout any movements
  - landings, cutting, decelerating

- Box Jump/Landing
  - "soft" landings
  - remember athletic stance
  - after jump down-hold position
  - Key component to neuromuscular training
  - incorporate into daily warm ups
  - always progress in a safe manner
Goal: To examine the effects of a neuromuscular training program on performance and lower-extremity biomechanics in female athletes.

Subjects: 53 high school females with an age range 13-17, 41 females were in the experimental group and 12 were in the untrained group.

Results: After the 6-week program there was improvement in performance, but also biomechanically. Prior to training females had a great deal of medial and lateral torques on landing. After training it was decreased. Right knee internal valgus torques decreased 28% and right knee internal varus torques decreased 38%.

Applications: This would be useful for ATC's in a clinical situation to help improve a female athlete's biomechanics, which in turn would help to decrease injury. Also, a coach could use this to increase performance for their athlete for a preseason and/or off season training program.

Goal: To decrease incidence of knee injury in female athletes after implementing a comprehensive training program.

Subjects: Total of 1263 athletes were monitored for injury. 366 girls on 15 teams participated in the 6 week preseason neuromuscular training program, 463 girls on 15 teams were just the untrained group, and 434 untrained boys who served as a male control group. All were high school students.

Results: there were 14 serious knee injuries among the 1263 athletes monitored. The untrained group demonstrated a higher incidence of serious knee injury than the male control group, but there was no significant difference between the trained and male control groups. The untrained group demonstrated an injury rate 3.6 times higher than the trained group and 4.8 times higher than the male control group.

- **Goal:** To determine if placing female athletes through a neuromuscular and proprioceptive training program would have an effect on preventing ACL injuries.
- **Subjects:** A two year study. 1041 female soccer players (52 teams) were in the trained group in year one, ages 14-18. The untrained group had 1905 female soccer players. In year two 844 subjects were used in the trained group and 1913 were in the untrained group.
- **Results:** Two ACL tears were reported in the trained group and 32 in the untrained in year one. 88% reduction of ACL injury compared to untrained group in year two there were four ACL tears in the trained group and 35 in the untrained group. 74% reduction.
- **Application:** This study directly relates a program to the prevention of ACL tears in female athletes. This would be used by an ATC in the clinical setting to help reduce their ACL injuries in their female athletes.

ACL injury prevention programs do work. More research is done everyday. Future looks good for ACL injury rates to decrease in female athletes!!!
• Please take this time to complete the post-test. Once you are finished please leave the post-tests at your table. You are free to go once you have finished. Thanks for your time.