The occurrence of ACL Injuries in High School Female Athletes and how they can be prevented

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Abstract

The Anterior Cruciate Ligament, also known as ACL is one of the four main ligaments in the knee. More specifically this particular ligament is responsible for the stability of the knee in the sense that is prevents the femur from passing over the tibia. This study was designed to examine the prevalence of high school female athletes rupturing or tearing their ACLs as opposed to their male counterparts, who don't experience this injury as often. The study further examined the relationship between the female biology along with various other factors that contribute to female high school athletes having a higher probability of tearing their ACL during athletic events. The participants of the study included all athletes from four local high schools known to have successful athletic programs, and varying playing surfaces. Results indicated that due to the various factors related to the female anatomy, females are two to ten times more likely to experience an ACL tear than their male counterparts (Dharamsi & LaBella, 2013). This study can serve as a contribution to the prevention techniques, understanding of ACL injuries, as well as how the female and male anatomies differ leaving female high school athletes with an increased risk of ACL injury.

Keywords:

-ACL

-Female

-Athletesn

-High School

-Prevention

Content

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Background of the Study

Anterior Cruciate Ligament, most commonly known as the ACL, is located in the middle of the knee and has the main purpose of keeping the knee joint stable. The ACL works with the Posterior Cruciate ligament, or the PCL, crossing under the ACL also assisting in the stability of the knee. More specifically, the ACL prevents the shin bone from sliding backwards under the femur. Recent studies have shown that there has be a continuous increase in the occurrence of receiving an ACL tear especially in adolescent female athletes.

The ACL is extremely important in athletes who require stability in running, cutting, and kicking. "The ACL deficient knee has also been linked to an increase rate of degenerative changes and meniscal injuries," (Gammons, 2014). Approximately 50% of patients with ACL injuries also have meniscal tears because of the violent motion the knee endures, resulting in the ACL injury (Gammons, 2014). It can be a very traumatic experience and effects athletes differently in the long run depending on commitment to recovery, along with biological reasons including the new graft not being accepted in the knee or if it gets too stretched out before recovery is complete.

These specific knee injuries are most often than not, a result of low-velocity, noncontact, deceleration injuries, when you slow down or change direction very sudden and/or rapidly accelerate after stopping, and contact injuries with a rotational component. An ACL injury is more prominent in people who participate in high risk sports such as basketball, football, skiing, and soccer. Contact sports such as these also may produce an injury to the ACL ligament secondary to twisting, valgus stress, or hypertension; which are all directly related to contact, impact, and/or collision. The chance of a "non-athlete" suffering from an ACL injury is 1,000 to

1, therefore almost exclusively happening to athletes (Gammons, 2014). The occurrence of an ACL injury can also be increased by the surface being played on. For example, a recent study done by Dev K. Mishra, President of Sideline Sports Doc, reveals that ACL tear rates are higher on artificial turf vs. grass fields (Mishra, 2013).

Female athletes have been known to have higher risk of injuring their ACL due to various factors such as the laxity in the ligaments, tendons, and muscle fibers all due to the female's genetic make-up. Females also in most cases, receive impact with their bones when coming down from jumping or stopping suddenly, rather than with their muscles as male counterparts tend to do. Other biological factors include the tunnel or "notch" that is at the end of the thigh bone where the ACL and PCL "live". These notches have been found to be narrower in females restricting the ACL from maneuvering in cutting/change of direction activities. Dr. Souryal from the University of Texas Southwestern Medical Center, was the first to describe the link between bony anatomy and ACL tears to describe the way of measuring it. He found from looking at these notches that those with narrow tunnels are at 26 times more risk than those with normal size notches. And in 1992, he found that females have proportionately narrower notches than males.

The only study on the prevalence of ACL injuries in the general population came to the conclusion that, approximately, one in 3,500 people tare their ACL a year. There is an estimated 200,000 ACL-related injuries that occur annually, with roughly 95,000 "new" ACL ruptures per year in the United States alone. There are about 60,000-75,000 ACL reconstructions performed annually (Gammons, 2014).

The likelihood of female athletes acquiring this specific injury has been found to be two to ten times higher than in male counterparts. With the segment of the population that accounts

for the highest number of ACL injuries occurring in female athletes ages 15-19 years (high school aged girls). Female high school sports that tend to be associated with the highest rates of ACL injuries are soccer, basketball, and gymnastics, which account for 11.7, 11.2, and 9.9 injuries per 100,000 athlete exposures (which is every time an athlete participates in a single practice or competition) (Dharamsi & LaBella, 2013). The National High School Sports-related Injury Collection, listed all sports and the rate of ACL tears finding that women's soccer is the most common sport that involves such tears (Gray, 2013).

Over the past 20 years, young athletes exposed to ACL injuries has increased mainly due to the growing number of children participating in competitive sports at increasingly young ages; along with exposure to more intense levels of training. There is a phenomenon called "sport specialization", this is essentially young athletes who only participate or "specialize" in a single sport all year round usually without a decent resting or recovery period. According to Malina Robert from American College of Sport Medicine, "Risk of early specialization include social isolation, overdependence, burnout, and risk of an over use injury." The continuous over use on the joints that are singled out due to only playing one sport, are receiving a significant amount of impact and overuse which in the long run have been found to result in early arthritis, meniscal damage and cartilage damage, along with ligament stress which weakens the ligament causing these athletes to be more prone to ACL injuries.

Statement of the Problem

ACL injuries are becoming more and more prominent in adolescent (high school aged) female athletes. There is research that has been shown that this ligament injury can be prevented if certain precautions are taken. The problem is that this research is still somewhat premature and minuscule, but there is still sufficient evidence that female athletes have strengthening

exercises and, in many cases, the equipment necessary to improve form and muscular strength throughout the legs that help to stabilize the knee more efficiently so that it is more resistant to impact and twisting injuries such as to the anterior cruciate ligament.

Purpose of the Study.

The purpose of this particular study is to explore various other studies and research to better understand why the phenomenon of ACL (anterior cruciate ligament) injuries in female high school athletes has become so prevalent throughout the nation. There is some "common" knowledge about contact and twisting as being the underlying cause of such an injury, but there is more to it; much of which is biological.

Many have witnessed, or have personally experienced, a high school female athlete tear their ACL either in training or in competition and have the understanding that this specific injury is more prevalent in females but are not exactly sure as to why. This study will enlighten anyone who wishes to learn more about ACL injuries, why it is more common in high school female athletes, why the prevalence of experiencing such injury has increased over the past 20 years, and what these athletes can be doing to prevent the rupture of this ever so important ligament in the knee.

Research Questions.

The following research questions (RQ) were developed to frame this study. The study examined the prevalence of ACL injuries in the nation, with the focus of the study based around high school female athletes; along with the various factors that contribute to ACL tears in this particular group of young females.

RQ1: Why are ACL injuries more common in high school female athletes?

RQ2: What factors contribute to the increase of ACL injuries in high school female athletes?

RQ3: Is there a way to prevent ACL tears?

Limitations of the Study.

There are few but sufficient limitations to this study that prevent us from gathering all of the information we could possibly want to know about high school female athletes and the occurrence of them receiving an ACL injury. This is a very timely study that must be done over multiple years with a large enough group of these girls to represent all high school female athletes in various sports to produce the most accurate results possible. Tests that need to be done to test for laxity in the ligament or to measure the notch where the ACL resides are all very expensive. This is where consent comes into play, as to most high school students are under the legal age and their parents would have to be involved which could lead to various complications. The list of some limitations follows.

1. Time
2. Financial resources
3. Lack of participants for the study
4. Parental consent form due to these athletes mostly being under 18 years of age

Review of the Literature

The contents of this chapter specifically address what happens in the knee as a result of an ACL tear, how sport specialization can contribute to athlete injury, why female high school students have a higher risk of suffering from an ACL tear as it pertains to their biology, and prevention techniques that have been found to help reduce the occurrence of such an injury. This chapter will go into further depth and will provide explanations for this increasing phenomenon along will multiple visualizations to help the reader really grasp the concept of the knee, specifically the ACL.

Rupture of the ACL

Ligaments are tough, non-stretchable fibers that hold your bones together. The whole purpose of the Anterior Cruciate Ligament, referred to as the ACL, is to stabilize the knee. The ACL does this by making sure that the femur does not go over the tibia or shin bone by connecting them and helps to stabilize the knee joint. The ACL also, runs diagonally through the center of the knee crossing over the Posterior Cruciate Ligament also known as the PCL. The rupture of this ligament typically occurs by sudden twisting movements, slowing down from running, or landing from a jump causing the ACL to stretch beyond its normal range (Stryker Corporation, 2015).

Most people who experience an ACL tear will hear a popping sound at the time of the injury due to the actual rupturing of the ACL itself. Followed by, the knee possibly giving way, rapid swelling, and in many cases, pain will occur. Other symptoms include an inability to move the knee normally along with felling unstable. Most will experience these symptoms above, while few will still be able to remain active and might only be affected when it comes to landing and sharp cutting. Factors that affect if someone is able to walk normally or at all, able to run, or

if their everyday life is largely affected or not at all, can depend on further additional trauma the knee experienced during the rupture of the ACL. For example, half of the ACL tears are accompanied by soft tissue damage to the meniscus and/or to the cartilage that absorbs shock to the knee joint. Damage to these soft tissue can result in increased swelling, lack of stability, and discomfort.

There is also the likelihood of further ligament damage to the PCL, LCL, and MCL which are three of the four ligaments that stabilize the knee joint. All of which can be repaired with surgery. Ligaments, unlike muscles, do not have their own blood supply and cannot heal themselves; and therefore the patient has two options. The first and most reliable, is surgery to return knee to its normal function and people can return to their everyday lives and can remain active. The second being, not getting surgery and just simply doing rehabilitation to build muscle around the knee which, in most cases, results in the need for a change of lifestyle and an ACL brace that restricts the knee from moving side to side (Stryker Corporation, 2015).

(See Figure 1)

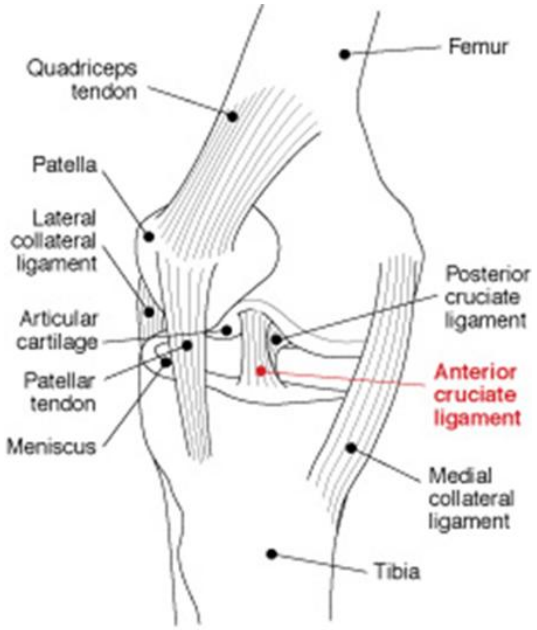


Figure 1: **Side View of the Knee**

Ligament A band of fibrous tissue that connects two or more bones at a joint.
Tendon Fibrous cords of tissue that connect muscle to bone.
Meniscus A C-shaped piece of cartilage that acts like a pad between the femur (thigh bone) and tibia (shin bone).
Sprain A stretch and/or tear of a ligament.
Strain An injury to either a muscle or a tendon.

(National Library of Medicine, 2008)

Female High School Athletes

Female athletes are known to have a higher risk of injuring their anterior cruciate ligament, or ACL, while participating in competitive sports. (See figure 3 for reference to high school boys vs. high school female athletes). The chance of ACL tear in female athletes has been found to be 2 to 10 times higher than in male counterparts. Variations in risk depend on the study population, including the particular sport. There are numerous theories about why women tear their ACL more commonly than men. The most recent research points to differences in the biomechanics (the way our bodies move) of male and female athletes. The good news, as you will read, is that we have the ability to change the likelihood of ACL tear.

Landing position: When women land from a jumping position, they tend to land with the knee in a straight position, transferring the force of impact to the knee joint. Men tend to absorb more of the energy of impact by landing with their knees bent. Women also have an increased valgus angle of their knees (a knock-kneed appearance) and movements of the extremity place more stress on the knee ligaments as a result of this alignment (Slauterbeck, 2003.) (Sutton and Bullock, 2013) (Hewett 1999).

According to the Centers for Disease Control and Prevention, nearly 30,000 girls age 19 and younger suffered ACL injuries that required surgical repair in 2006. While research cannot

pinpoint a definitive cause for the higher numbers of ACL tears in female athletes, there are many contributing factors. When athletes of either sex hit puberty (typically around the time they're freshmen in high school) they're asked to train harder than ever before. Their various sports become more intense not only in competition but in practice sessions as well. But girls often have bodies unequipped for such vigorous training.

As you can see in Figure 2, from the BMJ Publishing Group, the rate of female ACL tears spikes around age 14 (puberty), peaking for boys too but not near as much. Proving the statement that high school female athletes have a greater chance of suffering from an ACL tear.

As a boy's testosterone level increases, he naturally adds muscle and gets stronger. But as a girl's estrogen level increases, she adds more fat than muscle while her ligaments become more lax and susceptible to injury. Subsequently, girls don't naturally develop muscle necessary to keep their joints in safe and stable positions. There are however, strengthening exercises that have been proven to strengthen the muscle around the knee joint to improve stability and decrease the likely hood of experiencing an ACL tear (Berra, 2009). See figures 2 and 3

Another factor is anatomical, where the pelvis bone in females is wider than in males. This actually increases the angle to which the femur attaches to the tibia. Therefore, the steeper the angle, the more the knees rotate causing a “knock-kneed stance” that puts extra stress on the ACL (Cluett, 2013).

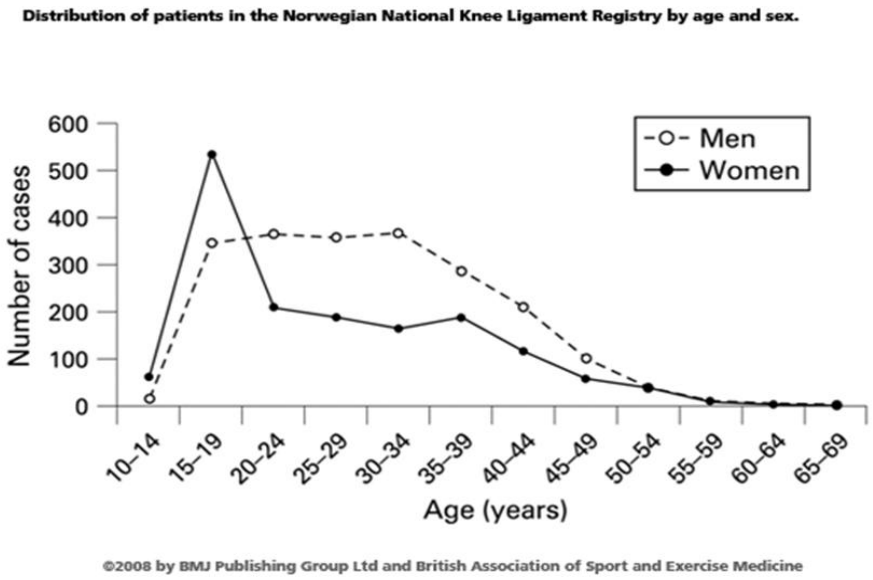
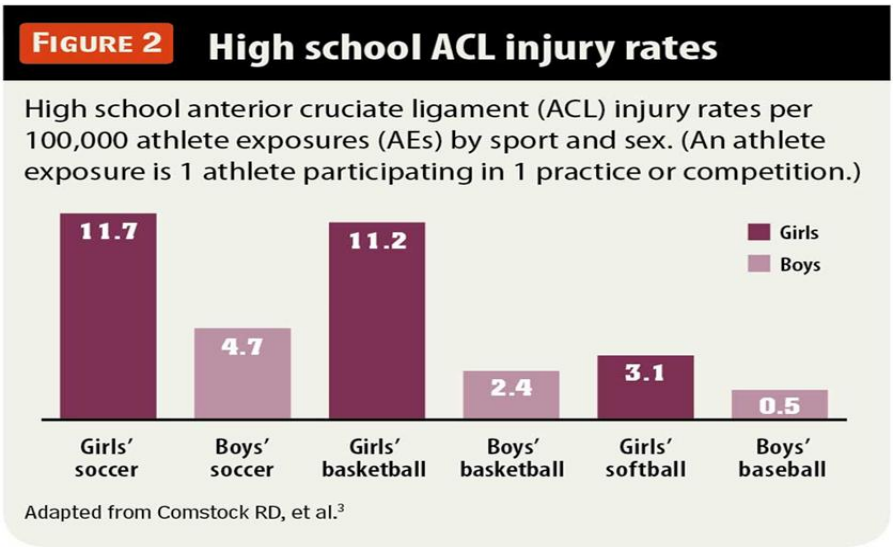


Figure 2:

Distribution of Knee Injuries by Age and Sex

The above charts illustrate a breakdown of ACL injuries statistics in men versus women, as well as a general breakdown of knee injury statics by age and sex. This data, collected by BMJ Publishing and the British Association of Exercise and Sports Medicine, shows that teenage women are at especially high risk of suffering a knee injury.

Figure 3:



(Dharamsi, 2013)

A further factor that is becoming known is the surfaces at which these athletes are performing on. A recent study done by Dev K. Mishra, President of Sideline Sports Doc, reveals that ACL tear rates are higher on artificial turf vs. grass fields (Mishra, 2013). The researchers found an "incidence rate of 1.42 ACL injuries per 10,000 athlete-exposures on artificial playing surfaces and an incidence rate of 1.24 per 10,000 athlete exposures on natural grass. The rate of ACL injury on artificial surfaces was 1.36 times greater than the injury rate on natural grass. Non-contact injuries also occurred more frequently on artificial turf surfaces" (Mishra, 2013). This is due to the substances the artificial surfaces are made out of. For example, artificial turf has five different layers starting from the top to the bottom with; yarn, rubber infill, sand, the elastic layer, and finally the sub base (Mishra, 2013). Turf has a tendency to give these athletes better traction which is good but it also means that when they are making quick changes in pace and/or direction, there is a higher likely hood of their foot staying stationary rather than turning as the body turns. Which is one of the main causes of ACL tears, non-contact. Therefore, along with the various biological factors, there are also many environmental factors that can have a large contribution to this very injury.

ACL Tear Prevention

Many times ACL tears happen to females that are in good physical shape, and in most cases to girls who are current athletes. So even though they are in great physical shape, their movement patterns are not very ideal for the stress that they put on their bodies in their athletics. This includes how girls, in most cases, tend to play more upright, rather than playing with their hips and knees bent in the "defensive stance". When playing in this position, and with any quick, and/or pivotal movement, there is a chance an ACL may be torn (Griffin, 2013).

Most doctors and athletic trainers believe that with education and training, ACL tears in girls can be prevented. It has come to be believed that if female athletes start training programs early enough and do them regularly, they can develop their major muscles in their legs such as hamstrings, quadriceps and gluteal muscles; which are the main knee joint stabilization muscles. They can also learn to accelerate, decelerate, jump, land, and cut in a much safer manner as they would be using their muscles rather than putting unnecessary pressure and impact on their knee joint. Dr. Griffin, a spokesperson for the American Academy of Orthopedic Surgeons says, "We can't change anatomy, but we can change the way girls move neuromuscularly" (Berra, 2009).

Research Method

The contents of this chapter outlines and defines the specific methodology that was used in researching and examining the occurrence of ACL tears in high school female athletes. This chapter also outlines the methodology which was used to identify the relationship between female high school athletes versus male high school athletes and the occurrence of experiencing an ACL rupture. The chapter outlines the design of the study, the participants used in the study, and the specific instruments used for the collection of the data.

The Study Design

This quantitative research was designed to be a study of the occurrence of ACL injuries in high school male vs. female athletes. The study was aimed at not only examining the occurrence of ACL injuries in male and female athletes, but to also reiterate that female high school athletes have a much higher probability of receiving an ACL tear. Data was gathered as a result of the application of the following instrument: The LaBella ACL questionnaire (LaBella 2015).

Research Questions

The following research questions were developed to guide the study which examined the frequency of ACL injuries in high school female athletes and why it is more common in females, the various factors that contribute to this injury being more common in females, and finally, to find out if high schools are taking preventative action to try to decrease the occurrence of ACL tears.

RQ1: Why are ACL injuries more common in high school female athletes?

H There is a statistically significant difference in the frequency at which female high school athletes suffer from an ACL tear.

H There is no statistically significant difference in the frequency at which high school female athletes suffer from an ACL tear.

RQ2: What factors contribute to the increase of ACL injuries in high school female athletes?

H There is a statistically significant difference in the various factors that contribute to high school female athletes experiencing an ACL tear.

H There is no statistically significant difference in the various factors that contribute to high school female athletes experiencing an ACL tear.

RQ3: Is there a way to prevent ACL tears?

H There is a statistically significant difference in ACL prevention techniques.

H There is no statistically significant difference in ACL prevention techniques.

Participants of the Study

The participants of the study were compiled from four high schools in the Frederick County public school system. These schools consist of (1) Urbana High School, (2) Tuscarora High School, (3) Linganore High School, and (4) Oakdale High School. Each of these schools have a high success rate in male and female athletics and experience ACL injuries often. These institutions were chosen because they are each 3A schools who have won State Championships in various sports within, meaning they have strong athletic programs and have a high probability of having athletes who experienced an ACL injury.

Institutions three and four each have artificial surfaces also known as turf fields. While institutions one and two have natural surfaced fields (grass fields) that tend to get pretty torn up from continuous use and not enough upkeep. As mentioned previously by Dr. Souryal, from the University of Texas Southwestern Medical Center, most ACL tears are results of twisting while the foot is firmly planted in the surface, quick changes of direction, landing while using your

joints rather than taking the impact with the major leg muscles. All of which are increased due to uneven surfaces. If these fields are not rolled out regularly and kept nice and flat, it is safe to assume that institutions one and two should experience a higher rate of ACL tears (See table 1).

Table 1

Institution	Female Athletes	Male Athletes
Urbana High School	52	80
Tuscarora High School	51	76
Linganore High School	56	85
Oakdale High School	58	83

Instrumentation/Survey

The study was conducted using a single survey with ten close ended questions. The survey was given to all of the athletes, both male and female, at each of these Frederick County High School Institutions so that a comparison can be made between male and female high school athletes. The instrument in its current format has ten items all with close ended answers so that the data could be easily collected and analyzed. It began with general questions to identify if the person was male or female then proceeded to ask which sport they played so that the sport with a higher likelihood of ACL injuries could be identified and so on. As the survey went on, it got more descriptive about ACL injuries and how much these high school athletes actually know about ACL injuries and ACL injury prevention.

Data Collection

The process of data collection required the researcher to create a survey using Survey Monkey. (https://www.surveymonkey.com/s/THGDNV2) (LaBella,2015)

Summary of the Methodology

The chapter provides information pertaining to the specific design of the study (a quantitative analysis) and a detailed description of the participants chosen for the study. The

instrument used in the study included the survey off of Survey Monkey, The LaBella ACL survey. Details have been provided that outline the data collection process.

Summary and Discussion

Summary of the Study

This study was conducted to explore various other studies and research to better understand why the phenomenon of ACL (anterior cruciate ligament) injuries in female high school athletes has become so prevalent throughout the nation. Focusing on the biology of females versus males in relation to the occurrence of ACL tears, why this particular injury is more prevalent in female HIGH SCHOOL athletes, as well as if there are ways to prevent such an injury from happening in the first place, and how to prevent it from happening again.

The way I was able to efficiently conduct the research regarding the prevalence of ACL tears in high school female athletes was to conduct a survey in four local high schools (Urbana High, Tuscarora High, Middletown High, and Oakdale High). These four particular schools were chosen because they have a fairly high number of ACL tears in various sports. They also have different surfaces to play on. A recent study done by Dev K. Mishra, President of Sideline Sports Doc, reveals that ACL tear rates are higher on artificial turf vs. grass fields (Mishra, 2013). The researchers found an "incidence rate of 1.42 ACL injuries per 10,000 athlete-exposures on artificial playing surfaces and an incidence rate of 1.24 per 10,000 athlete exposures on natural grass. The rate of ACL injury on artificial surfaces was 1.36 times greater than the injury rate on natural grass. Non-contact injuries also occurred more frequently on artificial turf surfaces" (Mishra, 2013). Which is why these four local high schools were chosen; two of these schools chosen for the study have artificial playing surfaces, while the other two currently have grass or natural playing surfaces.

The participants of the study include both male and female athletes at each of these four schools, so a correlation could be mapped out on the prevalence of ACL tears in High School female athletes versus that of the male athletes in their respective schools.

Discussion of the findings

The aim of this study was to look at the correlation and occurrence of ACL tears in high school female athletes and the various factors that contribute to this terrible injury. There has been a great deal of research done on this very topic as the rate of ACL tears are increasing. Researchers along with those affected by this injury are curious as to why this tear in such an important ligament to the body, occurs so frequently, thus the various studies and research conducted over time.

RQ1: Why are ACL injuries more common in high school female athletes?

RQ2: What factors contribute to the increase of ACL injuries in high school female athletes?

RQ3: Is there a way to prevent ACL tears?

If this study was to be conducted the expected findings would include, proving that high school female athletes do have an increased likely hood of experiencing an anterior cruciate ligament tear (ACL tear). Reasons for this occurrence vary from the surface they tore it on, contact with another player, impact or coming down on the knee wrong, a quick change of pace or direction where their foot was planted firmly in the ground as the change occurred resulting in the ACL being stretched past the point where it can bounce back, or due to the female biological make up along with one or more of the factors above that increase the probability of experiencing an ACL tear; especially as a high school female athlete. The findings also included

ways to prevent ACL tears by strengthening the major muscles in the legs to produce more stability for the knee joint.

Conclusions

Although the overall results of this study indicate that female high school athletes do tear their ACLs more frequently than their male counterparts, there are a few conclusions that can be drawn.

First, the sample size was fairly small, only being 541 high school athletes. There are millions of high school students and therefor the sample did not represent the population as well as it should have. These findings represent the local area and local high schools fairly well but questions could be raised about if climate or other factors such as if they played for certain club of or rec teams, have any effect on this as well.

Secondly, only current high school athletes were given the questionnaire which does not represent ACL injuries that people who are graduated from high school may have experienced. Which can also limit the findings as to why the rate of female athletes tearing their ACLs has increased over the years. We would need to look into the prevalence of ACL tears within the past ten to twenty years to really get a grasp on why this specific injury has become more common in high school female athletes.

Finally, the results of the study show that female high school athletes experiencing ACL tears can be related to their minstrel cycle, along with the severity of their periods and what underlying effect it has on the elasticity of the ligaments throughout the body. This could have been taken into account to see if there is a direct correlation.

Recommendations for Future Practice

1. This study can be utilized for further research, along with creating more of an awareness in coaches and parents so they can do everything in their power to help their adolescent teens avoid an ACL rupture.
2. The findings can be used to assist personal trainers, coaches, and therapists in ACL injury prevention, as well as the understanding that not everyone who tears their ACL reacts the same both physically and mentally.
3. Not only coaches and parents should be aware of the factors that contribute to ACL ruptures but the athletes themselves. If they have a better understanding about the biomechanics in their knees they will know their bodies a little bit better in the sense that they are not necessarily more cautious, but instead, aware of the possibility and the factors that can lead to ACL injuries.

Recommendations for Future Research

1. An extension of this study should be conducted using a larger sample of high school athletes.
2. Along with a larger sample size of high school athletes, graduated high school athletes should be taken into consideration and compared to current ones.
3. This study can also be replicated by using (1) sport specific athletes, (2) comparing female athletes to their male counterparts participating in the same sport, (3) a variation of surfaces should be taken in consideration, gym floor, artificial turf, natural of grass surface, even a rubber surface (track).

4. After sampling high school athletes, the question of whether they played club or recreationally should be asked so that it can be taken into account as to what levels these athletes are accustomed to playing (higher level vs. low).
5. A demographic extension of this study could be conducted by exploring the net income of the households to see if the ability to pay for trainers or high level club teams has a greater effect on the abilities of the athletes as it pertains to muscle training.

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