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Literature review of female anterior cruciate ligament injuries

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LITERATURE REVIEW OF FEMALE ANTERIOR CRUCIATE LIGAMENT INJURIES

by

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The Anterior Cruciate Ligament (ACL) has been studied in many different ways over the past few years. It is of such interest that it is easy to find information about it. The ACL has become injured more with the increase in sports participation not only with female athletes but also with male athletes. As sports continue to become more and more demanding for athletes, the increase of all types of injuries are likely to occur. Athletes now have to participate in one sport throughout the entire year in order to have a chance to play sports at some high schools. As this demand continues, the likelihood of injury to the ACL also increases.

An area of great interest to many different individuals has been the female athletes increased injury of a tear of the ACL. Many different reasons have been suggested for this including both intrinsic and extrinsic factors. In this review of different articles, all factors and possibilities will be explained along with what the ACL does exactly.

As with any injury, the recovery time is not well received by an individual. It is even more unpleasant for an athlete because of the possibility of a missed season or possibly a career ending injury. Even though an ACL tear is normally not career ending, it can still affect an athlete greatly. It takes a lot of physical and mental strength for an athlete to improve after an injury. With the ACL tear because it is more common, the treatment of it is becoming better understood along with the recovery and procedure are becoming more efficient.

The ACL is a ligament whose main purpose is to prevent anterior translation of the knee along with prevention of hyperextension, resistance of internal rotation of the tibia, and assists with stabilization of varus and valgus stresses (Dorizas & Stanitski,

2003, pp. 356). The length of the ACL varies from 25 to 35 mm long, 7 to 12 mm wide, and 4 to 7 mm thick (Griffin, 2001, pp. 507). The ACL has two bundles of fibers that start at the posterolateral femoral condyle and cross the notch of the center of the knee to end at the anterior medial tibia (Griffin, 2001, pp. 507).

The main mechanism of injury to the ACL being torn is usually non-contact involvement. When it happens though, it is most often in contact sports. These sports are volleyball, football, soccer, and basketball. The reason for this difference in the type of sport and how it happens involves the activities done in each sport. With these sports, there is usually a rapid change of direction or landing form a jump involved. The most frequent way that the ACL is torn is the athlete has a planted foot with the knee in an almost extended position (sometimes hyper-extended) (Griffin, 2001, pp. 508). An example is the foot is planted for a pivot and then the athlete cuts quickly resulting in an increased rotation at the knee. The tibia is generally rotated toward the inside or mid-line of the body while the knee is flexed greater than 90° (Griffin, 2001, pp. 508).

After the injury has happened, many other factors have to be examined to make sure the ACL is torn. The individual typical reports upon injury the ACL, that the person felt a "pop" followed by that that will decrease with time, effusion, and not being able to fully extend the leg (Griffin, 2001, pp. 509). Some other factors that are important to evaluate for comparison later on and to also understand how the injury affects the individual include: joint line tenderness, quadriceps definition (depending on how soon after injury the examination occurs), patellar instability, range of motion, knee alignment, and ambulation (Dorizas & Stanitski, 2003, pp. 359).

Before using any type of diagnostic testing, a physician can perform special tests to assess the ligament. Those special tests that are specific for ACL tears are Lachman's, anterior drawer, and pivot shift test. Without a positive end point established with these tests, the degree of the ACL tear can be determined. Some other tests that are generally done with examination are valgus and varus stress test (test the lateral collateral ligament and medial collateral ligament respectively) along with the posterior drawer (test the posterior cruciate ligament) (Dorizas & Stanitski, 2003, pp. 359). For diagnostic testing, a Magnetic Resonance Image (MRI) has to be done to be able to see the torn ACL along with any other damage to the knee.

An individual who has an ACL tear can have two options. The individual can choose to have or not have surgery. Before surgery is performed, the individual has to have minimal effusion, minimal pain, and the range of motion has to be close to full. If these things have been achieved, there is an increase rate of recovery. The surgical procedure has advanced dramatically over the years with very high success rate. There are three types of graft choices used for an ACL reconstruction. The first type and most commonly used with athlete because of the higher demand on the body is the patellar tendon graft. This graft is used more since there are bony end plugs that can be inserted into the femoral condyle and tibia that will grow and become part of the bone. The next type of graft choice is the semitendinosus and semimembranosus or medial hamstring graft. This graft is less likely to be used for an athlete because it tends not to be as tight in the knee as the patellar tendon graft. The final type of graft choice is a cadaver allograft. An ACL of a cadaver is used with increased likelihood of complications such as infection or rejection by the body because it can be detected as a foreign body.

An individual choosing not to have surgerical intervention could be because of activity level or the maturity level the individual is currently in the person's life. If the individual is still quite young and will be growing, then it is sometimes best to wait for the individual to grow to the person's almost full potential. With the non-operative individual, a rehabilitation program still could be beneficial to make sure the person has enough strength, range of motion, balance-and-coordination, and functional activity level for low- to mod-impact activities (Dorizas & Stanitski, 2003, pp. 360).

The possible factors leading up to an increased likelihood of an ACL tear for females has been studied at length. As mentioned previously, there are both extrinsic factors, intrinsic factors, and a combination of both. Some intrinsic factors are alignment of hip to foot, laxity, hyperextension, ACL size, femoral notch size and shape, hormonal changes, inherited skills, and coordination (Ireland, 2003, pp. 639). The factors that can be changed include: strength, conditioning, shoes, and motivation. A combination of both factors is an individual's ability to become more skilled, neuromuscular coordination, order of firing of muscles, and proprioception (Ireland, 2003, pp. 639).

The intrinsic factors have had more data collected on them because of the fact that they are more easily measured. The alignment of the body has a safe position with decreased chance of injury especially of the ACL. The safe position has muscle activity of the hip muscles utilizing the extensors, abductors, and gluteals, the knee muscles are using the flexors and hamstrings, while the tibial rotation is prevented with the plantar flexors, the gastrocnemius, and posterior tibialis being recruited to fire. The unsafe position has the muscles completely opposite of the safe with the hip muscle activity coming from the flexors, adductors, iliopsoas, the knee utilizing the extensors and

quadriceps, and the tibial rotation is created from the dorsi-flexors, peroneals, and tibial anterior muscles firing (Ireland, 2003, pp. 640).

The body alignment for the unsafe and safe position upon landing from a jump are completely opposite from each other as was the muscle activity. For a safe landing, the back should be in normal lordosis, the hips are flexed, neutral abduction and adduction, and neutral rotation, the knees should be flexed, the rotation of the tibia is in neutral, both feet should be in control, and the person is balanced. The unsafe landing position starts in the back with the spine in forward flexion and rotated to the opposite side of the body, the hips are in adduction and internally rotated, the knees are less flexed and have valgus alignment, the tibia rotation is external, and the landing is unbalanced with tone foot out of control (Ireland, 2003, pp. 640). (See Appendix, Figure 1)

A female athlete has been known to increase laxity in her ligaments, but the findings for laxity vary with each new type of research done. One study done in the 1970's found that male football players are at an increased rate of knee ligament tears that had looseness in the knee (Harmon & Ireland, 2000, pp. 288). With these findings, it led researchers to explore the possibility of the laxity, but with further studies, the correlation of injury to laxity wasn't found. There is a strong finding of females to be more lax than males though (Harmon & Ireland, 2000, pp. 289).

An anterior translation stress test is performed to determine how the anterior tibia moves in relation to the lower extremity muscle movement, meaning how the bone of the lower leg moves forward or backwards with walking (Huston, 1996, para. 6). This procedure is done to test for joint stability of the ACL. The studies done with this type of testing were indicative of increased laxity for women especially with basketball and

soccer players. One study done with 100 subjects was found to have the female with ACL injuries to have more translation of the tibia versus women with normal knees (Harmon & Ireland, 2000, pp. 289). Also, laxity has been linked to an increase with exercise. Therefore, female athletes have been linked to increased laxity versus males with the study of anterior-posterior translation. Along with translation is joint proprioception, this is decreased also with increased laxity leading to an increased risk of injury (Ireland, 2002, pp. 646).

The size of the ACL is related to the femoral notch size and shape. Notch width index is calculated by a ratio of the femoral intercondylar notch to distance between the femoral condyles (Harmon & Ireland, 2000, pp.293). The femoral notch has been related to increased ACL injuries that have been found to be not dependant on gender. An ACL that is smaller usual is in a smaller notch that has an increased chance of being impinged or increased forces from rotational stress (Harmon & Ireland, 2000, pp. 293). The width of the ACL tends not to correlate with the notch size therefore a smaller notch didn't relate to a thinner ACL (Ireland, 2002, pp 645). Females were found to have smaller ACL than males even with body weight being factored into the findings. Also, females have narrower femurs and notches compared to males with all heights of subjects being measured. With all these findings, any individual who has a smaller femoral notch is projected to have an increased risk for injury to the ACL. IN comparison, another study concluded that the ACL was smaller in females than males, but there wasn't any statistical difference between the femoral notch width (Ireland, 2002, pp. 646).

Biomechanical alignment plays a very large role in female injuries including the ACL. Females are known to have wider hips, increased femoral anterversion, shorter

femoral length, greater Q angles, more external tibial torsion, larger amount of overpronation, and a greater thigh-foot angle compared to males (Harmon & Ireland, 2000, pp. 292). (See Appendix, Figure 2) In some studies that were done, Q angle and femoral anterversion were found to have no correlation to ACL injuries, but there was found to be an increase in ACL injuries with increased thigh-foot angle. As an individual for both genders grows, the lower-to-upper body segment is ratio is greater for the lower body. Therefore, it could make the individual have less control of knee movement leading to patellofemoral disorders or an ACL tear (Ireland, 2002, pp. 644). With these findings, it is undetermined if anatomical differences really have any significant effect on ACL injuries.

Hormonal changes have been the most expanded area of study done on ACL injuries in females, and at the same time, it is one of the hardest to measure because of all the variables involved. Most of the time when the data is collected for this factor, it is quite awhile after the injury. Since it is not done right away, many females forget when their menstrual cycles were. There have been no true findings that hormones are a factor in ACL injuries with females, but some findings suggest an increase in injury during a certain time of the menstrual cycle. In the studies done, ACL injuries are documented to increase in the ovulatory phase (Ireland, 2002, pp. 643). Females who take oral contraceptives seem to have a decreased incidence of ACL tears during that same phase. The follicular stage is reported to have decreased rate of ACL injuries with one study while another found an increased rate of ACL injuries with one week before menses and just after menses (Ireland, 2002, pp. 643). The hormonal effect varies with each study, but estrogen has the strongest effect. When estrogen is greater than normal, the

production of fibroblasts and collagen is decreased therefore affecting the ligament (Ireland, 2002, pp. 644). Collagen not only affects the ligament, but other structures of the body including muscle and tendons. The effect on these structures leads to psychological effects of reaction times, firing of muscles efficiently, and level of playing aggression (Ireland, 2002, pp. 644).

Inherited skills and coordination involve neuromuscular activity. Females have been found to be less effective with stiffening their knees (Ireland, 2002, pp. 646). When the muscles are properly contracted and relaxed, there is less movement of the knee joint and a decreased chance of injury to the knee. Females tend not to contract their muscles to the extent of males and usually have weaker hamstrings. When performing a test of anterior-posterior translation, the quadriceps were initially recruited to prevent anterior tibial translation for initial knee stabilization instead of the hamstrings.

Females compared to males for muscle fatigue on anterior tibial translation exhibited an increased tibial displacement. With these results, it is concluded that fatigue is very instrumental in knee injuries and on physical demanding sports. The muscles that are used to prevent the translation are recruited in the same order as when not fatigued, but there is still an increase in anterior tibial translation (Ireland, 2002, pp. 646). In one group that did agility type exercises, the reaction times of the muscles improved along with the muscles that help to control the tibial translation. When females performed running cross-cutting and side-cutting compared with males, the females had a tendency to use less knee flexion, less hip flexion, more knee valgus, and less hamstring activation (Ireland, 2002, pp. 646). Females that were elite had a higher disposition to fire off the quadriceps first without fully activating the hamstrings versus collegiate females and

males and elite males. Therefore, this firing could contribute to ACL failure due to the tibial anteriorly translating. In relation to the quadriceps firing excessively, this increased contraction when in almost full extension over does comes the tensile strength of the ACL.

With all the intrinsic factors that occur, there is always the possibility of an injury of any type to the knee. The ACL has been the most studied because of the high risk of injury. The factors vary greatly with how the female is biomechanically built and what type of sport the individual is playing in along with the training for that sport. Intrinsic factors cannot be altered, and with the studies done, there is a combination of both intrinsic and extrinsic factors especially when dealing with neuromuscular relationships.

Extrinsic factors have not been focused on as much as intrinsic. The reason for this is mostly because of the fact that they can be altered to make the injury less likely to occur. These factors are also dependent on the individual's ability to want to change what the individual wants to do and not on what the individual inherited in life.

The first extrinsic factor that can alter how the individual lands is strength. As mentioned with the neuromuscular function, the quadriceps are stronger in females than the hamstring. Since the quadriceps muscles fire off first, the goal would be to strengthen the hamstring to produce a different recruitment pattern to prevent injury and anterior translation of the tibia. This is extremely important since hamstring activation is protective of the ACL (Harmon & Ireland, 2000, pp. 295). The muscle activation during landing for females is the one of the biggest contributors to ACL injuries.

Conditioning is also related to strength because of the fact that of muscle firing patterns along with muscle endurance. If an athlete isn't conditioned, there is the

increased risk of fatigue leading to increased injury since the joint stability is affected. There has been no evidence that reports females are less conditioned than male athletes, but the fact remains that with both genders if fatigue is present the injury risk increases.

The relationship between shoes and ACL injuries is continuing to be studied for the fact that it varies with each sport. Shoe frictional contact changes on every surface and varies with the weather conditions. There has been evidence that increased friction of the shoe to surface contact leads to increased injury because of the decreased possibility of a give when pivoting. Since a lot of ACL injuries are non-contact, the shoe to surface friction could be a larger contributor than previously suggested. It is also one factor that can be changed very easily.

Motivation for an athlete to want to play a sport is always a contributing factor to many different things. Playing any sport not only involves a physical challenge, but it also involves a psychological challenge. If an athlete doesn't want to participate, the athlete has a decreased chance of wanting to perform correctly. If the athlete isn't playing to the athlete's full potential, the risk of injury increases. This is because of not paying attention, playing incorrectly, and other things that the athlete does incorrectly. Psychologically the athlete wants to do well in order to play better and prevent injuries that need not occur.

Prevention is the key to any injury. ACL tears are always going to occur with the high demand that is placed on athletes at this current time in our society. Some things can be done to prevent the chance of ACL tears. A new training method that has shown to have great success is plyometric training because it concentrates on landing technique to increase the awareness of situations that put an individual at risk for an ACL injury

(Harmon & Ireland, 2000, pp. 296). It also helps to improve hamstring to quadriceps ratio with concentration on increasing hamstring activation. In one study done comparing females who went though the ACL prevention training and those who didn't, it was found that the ACL prevention trained females had a lower rate of knee injuries (Harmon & Ireland, 2000, pp. 296).

ACL tears can never be totally prevented. It is important for individual's to understand that certain things can be done to help minimize the risk of the injury occurring. This can be done by altering the extrinsic factor or by performing a prevention program. Intrinsic factors are not as easy to recognize because some have to be done with special test that aren't always done until after the injury such as hormonal changes. As with any injury, the research will continue to be altered as more preventative measures are done besides training techniques and bracing.

Female athletes have continued to progress in all sports, and they will continue to progress and be challenged. With continued research, these challenged can be met because of the prevention that can be done to decrease the risk of injury. The ACL is a ligament, and with all ligaments, there is always a risk of damage. The motivation for female athletes to improve will push the limit to how much the body will do to prevent an ACL injury from occurring. The continued progress of surgical repairs has been and will continue to be very instrumental in the progress of ACL research.

Appendix

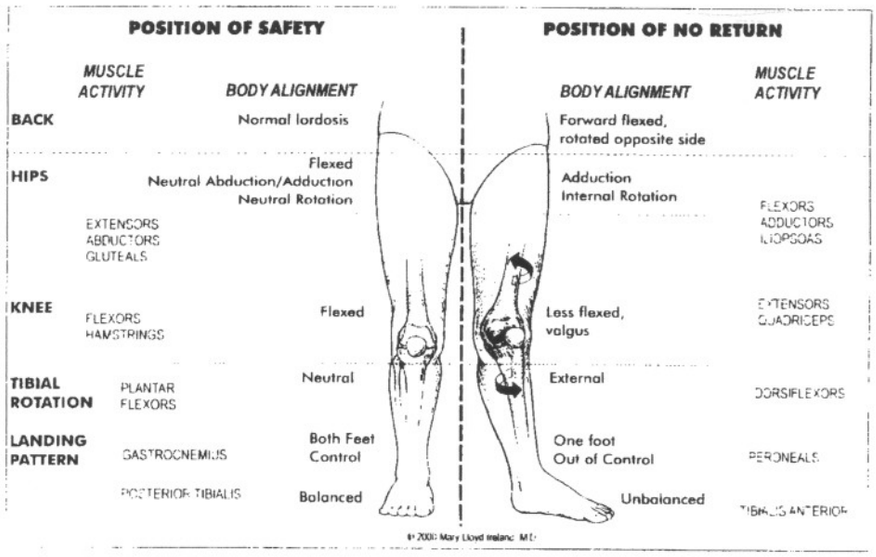

Fig. 4. The position-of-no-return mechanism for ACL injury and the safe position. (Copyright 2002, ML Ireland.)

Figure 1

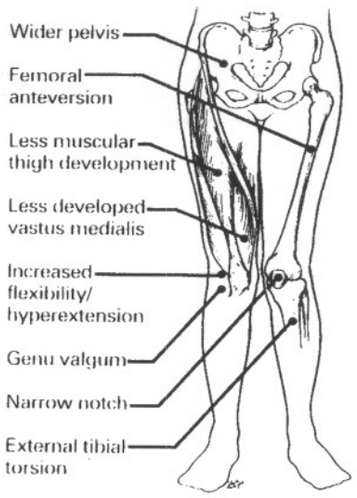

Figure 2. Lower extremity anatomic alignment in females. (*From* Ireland ML: Anterior cruciate ligament injuries in young female athletes: High risks call for new approaches. Your Patient & Fitness. New York, McGraw-Hill 10(5):Sept/Oct, 1996; with permission.)

Figure 2