

ISOKINETIC STRENGTH STATUS POST ANTERIOR
CRUCIATE LIGAMENT RECONSTRUCTION
HAMSTRING VS. PATELLAR TENDON AUTOGRAFT

By
Renita L. Patton

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The Graduate College
University of Wisconsin-Stout
Menomonie, WI 54751

Abstract

Patton Renita L
(Writer) (Last Name) (First) (Initial)

Isokinetic Strength Status Post ACL Reconstruction
Using Hamstring vs. Patellar Tendon Autograft

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The purpose of this study is to determine if differences exist in isokinetic knee strength between patients who are status post Anterior Cruciate Ligament (ACL) reconstruction utilizing the hamstring tendon or the patellar tendon autograft. The isokinetic strength will be evaluated using peak torque/body weight, total work and average power variables for both knee extension and knee flexion at five times during the first year status post surgery. Isokinetic assessment prompts the individual to exert as much force and angular movement as they can generate up to

a predetermined velocity. As per this assessment a particular muscle group may be exercised to its maximum potential throughout the entire range of motion (ROM). Autograft versus the post ACL reconstruction using the Inclusion criteria for patients are as follows: (1) status post ACL reconstruction with either a patellar tendon or hamstring tendon autograft, (2) age 16-40 years, (3) no meniscal repairs, (4) no other ligamentous reconstructions, (5) followed standard MedSport ACL reconstruction rehabilitation protocol and (6) signed the University of Michigan Patient Information Sheet. Patients will not be included who do not meet each of the above criteria. The data will be grouped by graft type (hamstring vs. patellar tendon) and time since surgery (12-19.9, 20-26.9, 27-32.9, 33-40.9, 41-55 weeks). Statistical differences will be determined utilizing a two-sample t-test within the groups over a specific time significance set at $p>0.05$.

This retrospective study will utilize data collected previously at patient follow up visits in the clinic. The intended state for an isokinetic test to be performed is that it is performed on a joint that has no swelling and elicits no pain when multiple stresses are applied. The patient must be able to produce maximal efforts throughout a pain free ROM. The clinic protocol for isokinetic testing requires a 10 minute warm-up on a stationary bicycle followed by a set of instructions to familiarize the patient with the equipment and what the test itself involves. The patient is then seated into the isokinetic device Biodex (Biodex Systems 2, Biodex Medical Systems, Inc. Shirley, N.Y.) and knee ROM is set from 90 degrees to 30 degrees of flexion. The uninvolved leg is tested first at 60 degrees/sec for 5 repetitions and then at 240 degrees/sec for 15 repetitions followed by the involved leg. Data results taken from the test using 60 degrees/sec only, will be used for this study. The myth that states 60 degree peak torque value represents strength while the higher velocity (240 degrees) represents functional endurance, is one misconception of isokinetic exercise because

determination of torque, work, and power is independent of test velocity.

- Torque represents the force produced about a joint's axis of rotation

- Work is the applied force times the distance of rotation

- Power is the time required to perform work

All of these factors are involved in the assessment of strength in the knee joint either prior to ACL reconstruction surgery and/or after. The results of the Biodex test helps to give background information on how the extensors (quadriceps) and flexors (hamstrings) are altered.

This study consists of subjects who used an autograft instead of an allograft.

Autografts are tissues donated from the patients' body, while allografts are tissues derived from cadavers. Using tissue from a cadaver has advantages like anything else as far as it elicits no risks, pain or scars from the donor site. The significance of using an allograft is that there is less discomfort post operatively and atrophy of the quadriceps muscles is greatly reduced. However, unlike using an autograft, allografts do increase the chance of infection.

Men and women were tested for this retrospective study by using the above criteria to determine if there was indeed, a difference between the two different ACL reconstruction techniques. These measurements will provide valuable information regarding isokinetic strength returns for the quadriceps and hamstrings musculature for both grafts. The results of this study will assist both the medical personnel and the patients considering the graft options and different procedures available for ACL reconstruction.

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Chapter I

The knee is one of the most complicated structures of the body. Although the knee is protected by various ligaments and tendons and muscles, it is vulnerable to stresses put upon it on a daily basis. The basic musculature of the knee consists of the hamstrings, the quadriceps, patellar tendon, gracilis, and sartorius.

The hamstrings musculature consists of three muscles: the semimembranosus, semitendinosus, and biceps femoris. The semimembranosus and semitendinosus when flexed rotate the lower leg on the femur. The biceps femoris (main lateral muscle) (Caillet, 1992) internally rotates on the lower leg on the femur as well.

The quadriceps muscles are especially involved in the kinetics of the knee joint. They consist of the rectus femoris, vastus intermedius, vastus lateralis, and vastus medialis oblique. (Greslamer & McConnell, 1998) The rectus femoris crossed the hip joint and the knee joint. The patellar tendon (patellar ligament) is also part of this musculature as it also is included within the rectus femoris. This particular muscle flexes the hip and also the knee joint.

The vastus intermedius and vastus lateralis both provide assistance with flexion of the knee. The vastus medialis oblique (VMO) serves as a major stabilizer for patellar tracking (Arnheim & Prentice, 1993) which also assists with stabilization of the knee.

Lastly, the sartorius is a long narrow band of muscle that helps to flex the hip and rotate the knee. The gracilis is another long narrow band that adducts the hip and flexes while medially rotating the hip at the knee joint. The knee capsule is large and shallow and can hold up to 40 ml of air without tension. Synovial fluid surrounds the knee joint providing nutrients and lubrication for the knee joint and the capsule. The ligaments supply the majority of the support while the muscles supply the kinetic

action. (Caillet, 1992)

The major ligaments providing stability in the knee consists of the following: the Anterior cruciate ligament (ACL), Posterior Cruciate Ligament (PCL), Medial Collateral Ligament (MCL), and the Lateral Collateral Ligament (LCL). Fig1-1 (Caillet, 1992). The ACL and PCL have been defined as being responsible for normal functioning and stability of the knee. Injury to these structures can trigger significant disability, thus the need for repair. The ACL attaches below and in front of the tibia; passing backwards it attaches laterally to the inner surface of the lateral condyle. (Fig 1-2, Arnheim & Prentice, 1993) The ACL prevents the femur (thigh bone) from moving posteriorly during weight bearing. It stabilizes the tibia against abnormal internal rotation and works with the quadriceps and hamstrings to further stabilize the knee joint.

The Posterior Cruciate Ligament (PCL) tends to be the stronger of the two. It crosses from the back of the tibia upward, forward, and medially, attaches to the anterior portion of the lateral surface of the medial condyle of the femur. The PCL resists internal rotation of the tibia and prevents hyperextension (extreme stretching) of the knee and femur sliding forward during weight bearing.

The menisci in the knee are two fibrocartilages embedded within the facets of the knee joint. They are located medially and laterally and serve as “shock absorbers”, for the knee. They help to stabilize the knee especially when the knee is flexed. The medial meniscus is C-shaped, while the lateral meniscus is O-shaped. These two fibrocartilages prevent grinding and friction that would generally occur between the femur, the tibia, and the fibula.

Lastly, the Medial Collateral Ligament (MCL) attaches above on the medial epicondyle of the femur and below on the tibia. The MCL prevents the knee from

valgus (bent outward) and external rotating forces. The Lateral Collateral Ligament (LCL) is actually shaped like a pencil (Arnheim & Prentice, 1993) and attaches to the lateral epicondyle of the femur and the head of the fibula.

With all of the stabilizing factors associated with the knee, there is still a chance for injury to occur. Injury to the ACL is one that can seriously disrupt the entire capsule. The ACL is most vulnerable when the knee is externally rotated and an outside force is applied. A common description of an ACL tear is generally stated by, a motion where the foot is planted and a sharp turn is made twisting the knee. As stated earlier an injury to the knee can be very detrimental and in some cases repair is needed to return the athlete to daily physical activities.

Anterior Cruciate Ligament ACL surgery can be done using the patellar tendon graft or the hamstring tendon graft. There have been many discrepancies as to which technique is the “preferred one” and it comes down to the decision of the surgeon and how the best outcome would be best achieved for each particular patient. (Internet: Graft options) These techniques have both advantages and disadvantages on a much wider spectrum.

The patellar tendon involves using the middle 1/3 of the patellar tendon. After moving this portion of the bone there is a substantial base which is then reconstructed to form the anterior cruciate ligament. This technique is known for compromising the integrity of the quadriceps tendon because of its location, connected to the patellar tendon. This may produce soreness, and a decrease in strength. The hamstring tendon graft utilizes the semitendinosus tendon to again, reconstruct the ACL. Since this technique involves the hamstring tendon, the hamstrings are compromised and then produce soreness and a decrease in strength just as in the patellar tendon technique.

Chapter II

There are numerous pieces of literature stating the results of patients having ACL reconstruction and the techniques that are used. As an example there have been studies done by Marshall et al in 1978 (Yasuda, Ohkoshi, Tanabe & Kaneda, 1992) who developed a technique using the patellar tendon in addition to the quadriceps tendon to produce more strength in the graft. In this particular technique muscle strength and the quadriceps torque had returned to normal by the first 12 months in men, but still did not reach the strength of the uninvolved knee. This led Marshall and his team of researchers to the current conclusion that hamstring tendon grafts have been preferred over the patellar tendon graft because it does not involve the knee extensors (quadriceps). Muscular strength is rarely determined in the postoperative phase because it is generally believed that quadriceps muscle contraction exerts an anterior drawer force on the tibia, meaning a forward shift. It was determined that an isolated quadriceps muscle contraction with the knee in 70 degrees or more flexion exerted a posterior drawer force on the tibia (Internet; Graft Options). This particular study favored the modified version technique by Marshall, which concluded that the graft is relatively weak. In the Marshall technique the patellar portion of the graft consists of the thin tendinous membrane and periosteum. (Internet; Graft Options) In the modified method that portion is reinforced with the wider, thicker, quadriceps tendon. The literature on this particular method proved effective on the part of the knee, but still put increased pressure on the knee, impairing the extensor tendons of the knee.

There was yet another study done to evaluate the outcome of two different techniques using autogenous tissue. As stated earlier allografts (Marder, Raskind &

Carroll, 1991) are said to undergo the same processes of necrosis and revascularization that the autogenous grafts (Yasuda, et. al. & Marder, et. al.) do and also require the same period of reduced loads. However, at the present time, autogenous grafts remain the most popular form of replacement of the ACL. Clancy and Marder et al would also suggest that autogenous patellar tendon grafts are the best available replacements for the ACL. There have been other techniques performed, but there are other factors concerning them such as patient selection, surgical techniques, and methods of follow-up procedures. Feaginet et al (Marder, et. al.) reported no significant differences in reconstruction with semitendinosus and gracilis graft and a patellar tendon graft should have tensile strength comparable to on another and to the normal ACL. The ACL provided primary restraint to the knee by resisting forward translation in the tibia by 86%. (Seto, Orofino, Morrisey, Medeiros & Mason, 1988) This is again another reason the knee becomes significantly unstable due to damage to any one of the stabilizing ligaments.

There was a study done to compare hamstring and patellar tendon grafts. (Steiner, Hecker, Brown & Hayes, 1994) This particular study accessed the tensile properties of hamstrings and the patellar tendon. Patellar tendon grafts were notable for their close to normal ACL stiffness. Patellar tendon grafts also seemed to fail, generally on the tibial side by bone blockage past screw interference or by the suture holes. Gracilis and semitendinosus grafts left with the natural attachments to the tibia tended to be weak because of failure by slow tearing away from their tibial insertions. One major factor that was observed was that the stiffness of the hamstring tendons, no matter how well fixed, was only approximately half the integrity of the normal ACL.

The symmetry of quadriceps and hamstrings muscular strength and work capacity was evaluated in yet another study. (Harter, Osternig & Standifer, 1990) The differences in isokinetic strength were expressed in terms of a mean quadriceps strength

index and a mean hamstring index. Results suggested that using the semitendinosus tendons in place of the ACL did not cause significant long term impairment of isokinetic hamstring strength nor did the patellar tendon graft tendon graft contribute to strength deficits in these studies. Overall studies show that with proper rehabilitation and exercise quadriceps and hamstrings muscles do eventually achieve approximate isokinetic strength to that of the “normal ACL.”

Chapter III

Subjects

The subjects consisted of 195 male and female (41 hamstring tendon and 154 patellar tendon) subjects with ages ranging from 16 to 40 years, (age=27.5 yrs, weight=164.38 lbs/hamstring, 174.02 lbs/patellar, height= 69.1 inches/hamstring, 69.4 lbs/patellar). All of these subjects met the previously mentioned criteria. This being a retrospective study, the patients were not directly involved, except for the data obtained from patient follow-up charts.

Instruments

Biodex (Biodex Systems 2, Biodex Medical Systems, Inc. N.Y.) apparatus, which performs isokinetic tests in the body was utilized in this study. Isokinetic exercise was developed by James Perrine and introduced into scientific literature in 1967 by Hislop and Perrine. Isokinetic devices allow individuals to exert as much force and angular movement as they can generate up to a predetermined velocity. Thus only the velocities tested were at 60 degrees per second and at 240 degrees per second. The velocities were predetermined to test through a particular range. The limb rather than the muscle is moving at a constant rate throughout the entire range of motion which is also one of the major advantages of isokinetic exercise. In isokinetic exercise testing there is one fixed resistance to move produced by the patient so as not to overexert and/or increase pain.

Testing

Results from the Biodex test of each subject were used for one particular time frame (26.9 weeks). At this time the peak torque for hamstrings and quadriceps were tested on both the involved and uninvolved leg to determine a difference in strength between the two groups and also between the techniques. The results of the number for patellar and hamstring tendon grafts were listed and sorted as to determine if there was

difference in strength of the quadriceps and hamstrings of each graft technique. The mean values were calculated using the differences between the hamstrings (uninvolved vs. involved) and the quadriceps mean values were calculated using the same technique. A two sample t-tests was used to determine the results for the different groups over one specific time (26.9 weeks) post ACL reconstruction. There was a difference between the groups over time that was greater within the group of those who had undergone a hamstring tendon graft and as far as the comparable strength of the hamstrings.

Chapter IV

I found that there was a statistically significant difference in the strength deficit of the hamstrings when the hamstring tendon was utilized for the ACL graft. The hamstring peak torque measures $p=.0199$ while the patellar tendon peak torque measures $p=1.7366$. Even though these numbers prove to be statistically significant that there is a difference, that difference is very minute when looking at the broad spectrum. Of those individuals who received a hamstring tendon graft there was a 4.2% deficit in strength of the hamstring tendon and of those who received the patellar tendon graft only showed a 2.0% deficit in the hamstrings. The individuals who received a patellar tendon graft had a 21.18 % deficit in the quadriceps while there was only a 7.13 % deficit in the hamstrings of the same group. The numbers shown here do indicate there is a difference between the two grafts but the differences are not so drastic as to prove that one technique is better than the other.

Chapter V

Within the data selection there were only a few individuals who truly had an isolated ACL reconstruction. The other subjects had other elements involved within the ACL reconstruction such as debridements, which is a cleaning out of loose unwanted particles and tissues within the joint. These elements did not prove significant enough to change the results. There was a broader base of numbers for the patellar tendon graft than for the hamstring tendon graft and that may or may not have influenced the results. Also, the fact that this particular study reflects the numbers from men and women could lead to the results that there could be another avenue that could be explored. The percentages are significant to work with as far as to give education to therapists, surgeons, and also patients considering ACL reconstruction showing that there is a difference but the results still prove to be a decision between the patient and the physical therapist and/or doctor. It is not my objective to suggest one technique over the other; it was my objective to provide some numbers to work with in suggesting the statistics for the surgery. With these numbers readily available there are still some other pending circumstances that could be used for future research. The future research could be taking into account how sedentary the individuals were and how many of them were reasonably active before surgery. The deficits could be contributed to the amount of strength pre-surgery relative to the amount of strength post surgery and also as stated earlier, the fact that there were men and women involved.

Conclusion

There was a significant difference in the peak torque of the hamstrings of those who had ACL reconstruction utilizing the hamstring tendon technique. There was also a deficit in the quadriceps in those individuals who had undergone ACL reconstruction utilizing the patellar tendon technique. The research suggest that it is obvious that

when a portion of a tendon and or a muscle is removed there will be a deficit in that area. The results taken in this study were taken at approximately 25 weeks post ACL reconstruction. Perhaps if tests had been run at a different time post surgery there would have been less of a statistical difference. Evidence supports the fact that there will be a noticeable deficit post ACL reconstruction in either the hamstrings or the quadriceps depending on the graft of choice and rehabilitation could decrease the deficits considerably. Correct instruction of the rehabilitation techniques also need to be involved in the process and must be explained to the patient that the entire process could take anywhere from six months to a year to fully recover from the trauma. Research is still pending and could always be an issue in this situation of what technique should be used and what the outcome may be. We must all remember that there are risks involved with any surgery and the outcome is based upon the intrinsic and extrinsic factors involving the patient.

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