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Is the use of Eccentric Training in Combination with Traditional ACL Rehabilitation Programs More Effective than Traditional ACL Rehabilitation Programs Alone at Improving Overall Knee Function in Post-ACL Reconstruction Patients?

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A SELECTIVE EVIDENCE BASED MEDICINE REVIEW

In Partial Fulfillment of the Requirements For

The Degree of Master of Science

In

Health Sciences – Physician Assistant

Department of Physician Assistant Studies
Philadelphia College of Osteopathic Medicine
Philadelphia, Pennsylvania

December 13, 2019

Abstract

Objective: The objective of this selective EBM review is to determine whether or not eccentric training in combination with traditional ACL rehabilitation programs is more effective than traditional ACL rehabilitation programs alone at improving overall knee function in post-ACL reconstruction patients.

Study Design: A systematic review of three randomized control trials (RCTs) published between 2009 and 2018. The studies were all written in the English language and located in peer reviewed journals.

Data Sources: Three randomized controlled trials (RCTs) which evaluated the effectiveness of eccentric exercise as better rehabilitation in combination with traditional ACL rehabilitation for post-ACL reconstruction patients as compared to control groups only completing traditional ACL rehabilitation. All studies were found using PubMed.

Outcomes Measured: The primary outcome of all three studies was overall knee function which was measured using patient self-reported questionnaires based on their level of knee function. The scales included questions regarding symptoms, activities of daily living, quality of life, and disabilities. The questionnaires used were the Lysholm Knee Scale, Anterior Cruciate Ligament-Quality of Life Questionnaire (ACL-QOL), and International Knee Document Committee (IKDC).

Results: The study by Harput et al. (*Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*. 2018;1-8. doi: 10.1007/s00167-018-5040-1) shows no significant difference between IKDC scores between the group completing eccentric exercise in combination with traditional ACL rehabilitation compared to the group performing traditional ACL rehabilitation alone ($p>0.05$). The study by Kinikli et al. (*Acta Orthopaedica et Traumatologica Turcica*. 2014;48(3):283-289. doi:10.3944/AOTT.2014.13.0111) shows a significant difference in overall knee function between patients in the study group who completed eccentric exercise and traditional ACL rehabilitation compared to those in the control group ($p=0.002$ for the Lysholm Knee Scale and $p=0.000$ for the ACL-QOL scale). The study by Papandreou et al. (*J Orthop Surg Res*. 2009;4(1):2. doi: 10.1186/1749-799X-4-2) also found statistical difference between the study and control group in Lysholm Knee Scale scores ($p=0.03$).

Conclusion: Although the results of these three studies vary, eccentric training has the potential to be beneficial in post-ACL rehabilitation. However, further research is needed to evaluate if eccentric exercise could improve knee stability, overall knee function, and decrease re-injury rates.

Keywords: Eccentric therapy, eccentric education, cross-education, and ACL reconstruction

INTRODUCTION

The anterior cruciate ligament (ACL) is a ligament in the knee connecting the femur and the tibia and is crucial for knee stability. This dense band of connective tissue runs from the posterior aspect of the lateral femoral condyle to the fossa on the anterior tibia. The ACL provides knee stability primarily by inhibiting anterior translation of the tibia but also limits medial and lateral rotation of the knee joint. ACL tears are a very common sports related injury in the United States. It is estimated approximately 100,000 tears and reconstructions occur in the U.S. annually.¹ An exact total healthcare cost of ACL rehabilitation has not been identified; however, in a study published in *Sports Health*, it was found the per patient average charge (PPAC) for 6 months of post-ACL reconstruction rehabilitation was \$1,876.² Considering 100,000 annual ACL reconstructions, approximately \$187.6 million is spent in the U.S. on ACL rehabilitation annually.¹

ACL tears can be treated operatively and non-operatively. Anterior cruciate ligament reconstruction (ACLR) is the mainstay of treatment for full ACL tears and severely debilitating partial tears. ACLR is an arthroscopic surgical procedure that replaces the native ACL with an allografted or autografted tendon in its place.³ The large majority of patients undergo surgical repair for an ACL tear, especially athletes, younger populations, or patients who need to get back to their pre-injury level of function. Non-operative treatments, such as rehabilitation without reconstruction and bracing, are usually reserved for older, less active patients, or patients with history of osteoarthritis or other knee disorders.

After reconstruction, patients begin an ACL rehabilitation program lasting approximately 4-9 months. The hospital, surgical center, etc. where the ACL reconstruction surgery was performed, refers the patient to physical therapy for ACL rehabilitation. At physical therapy, the

patient performs various exercises activating different muscle groups, all in the hope to regain strength and stability of the knee. These trainings involve functional exercises, low load exercises, and limited strength training.⁴ Completing an ACL rehabilitation program involves close follow-up with physical therapy, which becomes very expensive and a large time commitment for the patient. Rehabilitation programs usually include 3-5 sessions per week. It has been reported 93% of patients have at least 17 post-operative ACL rehabilitation sessions.² Taking the 100,000 ACLRs performed annually in the U.S. into consideration, approximately 1.7 million ACL rehabilitation appointments happen every year.¹

Post-op ACLR rehabilitation is essential before returning to sports/physical activity. It is known post-ACLR patients experience decreased strength, decreased stability, and are at increased risk for another ACL injury.⁵ It has been reported almost 30% of patients who underwent ACLR and proper ACL rehabilitation experienced a re-rupture of their ACL graft within 2 years of returning to their sport.⁶ Attending ACL rehabilitation is more beneficial than not exercising at all, however it is unknown what exact type of exercises, stretches, and strength training is best to regain knee function, decrease pain, and get patients back to pre-injury level.⁴ Research is being conducted about various training programs to find the most effective combination of exercises, and the ideal length of rehabilitation. The goal is to find the best program to lower reinjury rates in athletes, and increase overall knee function. Frequent eccentric exercise is one of the training programs being researched.

There are two main types of muscle contractions: isometric and isotonic, with the latter being divided into concentric and eccentric. Isometric contractions are contractions of a muscle where the muscle is held at a constant length (not shortened or lengthened.) An example of a common isometric exercise is a wall squat. Isotonic contractions are those in which the muscle

changes length as it is contracted. Concentric exercises shorten the muscle fibers, such as during the flexion of a bicep curl. Eccentric exercises lengthen the muscle fibers, such as during the extension portion of a bicep curl.

Weight and strength training tend to focus on the concentric aspects of exercise more than eccentric portions. For example, in many workout regimens the athlete is evaluated by how many repetitions they can currently perform compared to the start of the training program. Increased repetitions are an important aspect of training, however by only using that measure of improvement, the importance of eccentric exercise is overlooked. To increase repetitions, athletes are speeding through the deaccelerations (i.e. lowering oneself into the squat position) to get to the acceleration portion (i.e. exploding up from the squat position.) This negatively impacts athletes, because it has been shown controlled, voluntary eccentric exercises are beneficial to workout regimens.⁷ There has been research to see if eccentric training can also positively impact ACL rehabilitation. This paper evaluates three randomized controlled trials (RCTs) analyzing the efficacy of eccentric training in combination with traditional ACL rehabilitation, as better rehabilitation for post-ACL reconstruction patients compared to control groups only completing traditional ACL rehabilitation.

OBJECTIVE

The objective of this selective EBM review is to determine whether or not the use of eccentric training in combination with traditional ACL rehabilitation programs is more effective than traditional ACL rehabilitation programs alone at improving overall knee function in post-ACL reconstruction patients.

METHODS

This systematic review analyzes three RCTs selected from PubMed peer reviewed journal. These articles were all published in English and found using the keywords “ACL reconstruction,” “cross-education,” “eccentric therapy,” and “eccentric exercise.” RCTs published in 2008 or later were inclusion criteria for the search, whereas all studies published in 2007 or earlier were used as exclusion criteria. The studies selected displayed relevance to the topic and specifically examined if eccentric training is effective in regaining overall knee function post-ACL reconstruction. In addition, the article-reported outcomes must qualify as POEMs (patient-oriented evidence that matters). Statistics analyzed in the three studies include p-values, mean changes from baseline, and Cohen’s d.

The population for all three studies includes male and female adult patients who have undergone ACL reconstruction. The intervention used in the studies varied slightly, but all included traditional ACL rehabilitation programs in combination with eccentric training. Harput et al. had patients complete a traditional ACL rehabilitation program along with eccentric training 3 days a week for 8 weeks.⁵ Kinikli et al. had subjects complete a traditional ACL rehabilitation program along with eccentric and concentric exercise 3 days a week for 12 weeks.⁴ Papandreou et al. had patients complete a traditional ACL rehabilitation program along with eccentric training 5 days a week for 8 weeks.⁷ The control groups were the same in all three studies and consisted of patients only completing a traditional ACL rehabilitation program. Outcomes measured in all three studies include overall knee function, which was obtained by patient reported questionnaires including the Lysholm Knee Scale, Anterior Cruciate Ligament-Quality of Life Questionnaire (ACL-QOL), and International Knee Document Committee

(IKDC). See Table 1 for inclusion and exclusion criteria along with further demographics and characteristics of the individuals in the three studies.

Table 1. Demographics & Characteristics of Included Studies

Study	Type	# pts	Age (yrs)	Inclusion Criteria	Exclusion Criteria	W/D	Interventions
Harput ⁵ (2018)	RCT	48	17-45	BMI: 26.1±3.2 kg/m ² , patients who had undergone ACL reconstruction with hamstring tendon autograft, sustained ACL tear in a non-contact injury mechanism, pre-injury Tegner score ≥ 5	ACLR with patellar tendon autograft or allograft, revision of ACLR, ACLR with meniscus and/or cartilage repair, systemic or neurological problems, LE injuries in contralateral LE ≥ 12 months ago	0	Traditional ACL rehabilitation with 8 weeks of eccentric training 3 days a week
Kinikli ⁴ (2014)	RCT	39	18-44	Patients had to have had ACLR with autogenous semitendinosus and gracilis tendon grafts, reconstruction surgeries had to be within 02/2010 & 05/2012, Tegner activity score of ≥ 4	Patients with additional ligament or meniscus injury, or previous history of knee surgery	6	Traditional ACL rehabilitation with 12 weeks of eccentric and concentric training 3 days a week
Papandreou ⁷ (2009)	RCT	42	20-25	Patients sustained a unilateral ACL rupture without other injuries needing reconstruction, Tegner activity score questionnaire and ranged from 0–5 level	Leg length differences, history of lower extremity pain in the last 6 months that was not related to the ACL, painful knee ROM, and joint swelling	0	Traditional ACL rehabilitation with 8 weeks of eccentric training 5 days a week

OUTCOMES MEASURED

All three studies' primary outcome was overall knee function. This was assessed using self-reported questionnaires patients answered based on their individual level of knee function. The three questionnaires used were the Lysholm Knee Scale, Anterior Cruciate Ligament-Quality of Life Questionnaire (ACL-QOL), and International Knee Document Committee (IKDC). Harput et al. reported their outcomes using the IKDC scale. This scale contains 10 topics related to knee symptoms, daily activities, and sporting activities that get converted to a scale of 0-100, with 100 being more highly functioning.⁵ Kinikli et al. reported their overall knee function using the Lysholm Knee Scale and ACL-QOL. The Lysholm Knee Scale contains questions regarding limping, pain, crutch support, giving way, locking, squatting ability, swelling, and stair climbing ability.⁷ Scores are ranked on a scale of 0-100, with 100 being more highly functioning. The ACL-QOL is a 31-question scale asking questions pertaining to symptoms, work concerns, recreational/sport activities, life style, and social/emotional feelings.⁸ Again, scores are ranked on a scale of 0-100, with 100 being more highly functioning.⁸ Papandreou et al. also used the Lysholm Knee Scale to evaluate overall knee function. The studies also recorded other outcomes such as quadriceps contraction strength, quadriceps accelerated reaction time, one leg hop distance, and vertical jump as outcomes. However, these are not POEMs and will not be evaluated in this paper.

RESULTS

Three RCTs were used to determine whether eccentric exercise in combination with traditional ACL rehabilitation is more effective than traditional ACL rehabilitation programs alone at improving overall knee function in post-ACLR patients. The Harput et al. study included 48 patients between the ages of 17-45 who had undergone ACL reconstruction with hamstring

tendon autograft and had sustained an ACL tear in a non-contact mechanism.⁵ Patients were randomly allocated to a group, and patients and trial workers were kept blind to the treatment. No patients withdrew from the trial. All participants completed a traditional ACL rehabilitation program starting at the fourth week post-op. In addition, the study group completed 8 weeks of eccentric training at a regimen of 3 days a week that also began at post-op week 4.⁵ The participants completed the IKDC form at 24 weeks post-op, but never completed the form at an earlier time. Therefore, no baseline is recorded in this study. Post-operative IKDC scores were analyzed, and no statistical difference was found between the study and control group, as seen in Table 2.⁵ A p-value <0.05 was considered significant.

Table 2. Efficacy of Eccentric Exercise and Traditional ACL Rehabilitation in Comparison with Traditional ACL Rehabilitation Alone for the Improvement of Overall Knee Function in Post-ACLR Patients, as measured by the IKDC score, conducted by Harput et al.⁵

Study: Harput et al.			
IKDC Score	Study Group	Control Group	p-value
Post-operatively	84.1 ± 9.4	79.4 ± 9.3	>0.05

The Kinikli et al. study had 39 participants from the ages of 18-44 years old.⁴ Patient's ACLR had to be completed with autogenous semitendinosus and gracilis tendon grafts. Reconstruction surgeries had to fall between February 2010 and May 2012. Patients were randomly allocated to the control or study groups and were kept blind. However, the clinicians were not kept blind during the study.⁴ Six participants withdrew from the study for the following reasons: lost to follow-up, too busy, or having too far of a commute.⁴ Worst-case analysis was not mentioned during the paper, so it must be assumed this was not performed. All participants completed a traditional ACL rehabilitation program starting at post-op week 3. In addition, the study group completed 12 weeks of eccentric and concentric training 3 days a week, also starting

at post-op week 3.⁴ The Lysholm Knee Scale and ACL-QOL questionnaires were completed pre-operatively and 16 weeks after the surgery. Mean change from baseline was the primary statistic analyzed. Post-operative Lysholm Knee Scale and ACL-QOL scores were analyzed and statistical difference was found between both study and control groups, as seen in Table 3.⁴ A p-value <0.05 was considered significant.

Table 3. Efficacy of Eccentric Exercise and Traditional ACL Rehabilitation in Comparison with Traditional ACL Rehabilitation Alone for the Improvement of Overall Knee Function in Post-ACLR Patients, as measured by mean change in baseline from the Lysholm Knee Scale score and ACL-QOL Score, conducted by Kinikli et al.⁴

Study: Kinikli et al.			
Lysholm Knee Scale Score	Study Group	Control Group	p-value
Pre-operatively	58.25 ± 13.84	63.29 ± 9.80	0.240
Post-operatively	88.31 ± 3.53	80.76 ± 8.30	0.002
Mean Change from Baseline	30	17	
ACL-QOL Score			
Pre-operatively	24.28 ± 8.60	36.19 ± 10.92	0.002
Post-operatively	56.79 ± 1.97	51.95 ± 3.60	0.000
Mean Change from Baseline	32	12	

The Papandreou et al. study was comprised of 42 individuals from the ages 20-25 years old.⁷ Patients who sustained a unilateral ACL rupture needing reconstruction without any other injuries were included in the study. Patients were randomly allocated to a group, but were not kept blinded to their placement. However, the physical therapists conducting the training were kept blind. No participants withdrew during the trial. All patients completed a traditional ACL rehabilitation program starting at post-op week 2. In addition, the study group completed 8 weeks of eccentric training 5 days a week, also starting at post-op week 2.⁷ The Lysholm Knee Scale was completed 3 days pre-operatively and 8 weeks post-operatively. Cohen's d and mean change from baseline was performed using patient's Lysholm Knee Scale scores. Post-operative

Lysholm Knee Scale scores were analyzed and statistical difference was found between the study and control group, as seen in Table 4.⁷ A p-value <0.05 was considered significant.

Table 4. Efficacy of Eccentric Exercise and Traditional ACL Rehabilitation in Comparison with Traditional ACL Rehabilitation Alone for the Improvement of Overall Knee Function in Post-ACLR Patients, as measured by mean change in baseline from the Lysholm Knee Scale score, conducted by Papandreou et al.⁷

Study: Papandreou et al.				
Lysholm Knee Scale Score	Study Group	Control Group	p-value	Cohen's d
Pre-operatively	78.00 ± 9.70	76.00 ± 9.70	0.01	
Post-operatively	90.57 ± 6.16	84.78 ± 6.91	0.03	3.78
Mean Change from Baseline	12	8		

DISCUSSION

ACL tears are expensive, debilitating injuries that require extensive rehabilitation to get a patient back to their pre-injury level. At this point in time, there is no optimal protocol for athletes to follow to ensure they can get back to their full functioning level.⁴ This selective evidence-based medicine review evaluated whether or not incorporating eccentric exercise with traditional ACL rehabilitation programs could be an effective training program for post-ACLR patients. The data collected showed promise for eccentric exercise being a beneficial part of ACL rehabilitation. Two of the three studies showed patient's felt they had better overall knee function after doing both eccentric and traditional training programs. While Harput et al. did not show a statistical difference between the control and study groups IKDC scores, there was no negative association with the addition of eccentric exercise.⁵ The research gathered in these articles demonstrates more studies need to be performed regarding the use of eccentric exercise for ACL rehabilitation. However, based on these results, it is a strong possibility overall knee

function and patient satisfaction would increase if eccentric exercise became a standard component of ACL rehabilitation.

Limitations

Although many positives came from these studies, limitations were identified in all three RCTs. First, all three studies only included patients 17 years old or older. However, ACL tears are not solely an adult injury. ACL tears also affect young athletes; in fact, the number of pediatric ACL injuries has risen in recent years.⁹ Therefore, studies involving the use of eccentric exercise in ACL rehabilitation for pediatric post-ACLR patients will also need to be conducted to help determine the effectiveness of eccentric training.

Two other limitations affecting all three studies were the length of the intervention and the very small population size. Harput et al. has the largest sample size, and it was only 48 patients.⁵ As previously mentioned, traditional ACL rehabilitation programs last between 4-9 months. Two of the studies implemented their intervention for only 8 weeks, and the third study conducted eccentric exercise for 12 weeks. Therefore, these studies only analyzed the benefits of eccentric training for 2-3 months, which is significantly shorter than traditional ACL rehabilitation. To see the full benefits of adding eccentric training to ACL rehabilitation regimens, studies would need to be conducted incorporating eccentric exercise throughout the whole rehabilitation period. The small sample size and short length of eccentric training both lessen the significance of the results found in the studies.

Another important limitation of the Kinikli et al. study and the Papandreou et al. study is the control and study groups showed significant differences pre-operatively. The Papandreou et al. study found a p-value of 0.01 in the pre-operative Lysholm Knee Scale scores between the two groups.⁷ The Kinikli et al. study showed no statistical difference in the pre-operative

Lysholm Knee Scale scores, however did show a p-value of 0.002 between the control and study group for the ACL-QOL pre-operative scores.⁴ This is concerning because it shows the two groups were different before the intervention took place. Therefore, it is unknown what effect the eccentric training really had because the statistical difference between the groups post-operatively could be contributed to the pre-operative scores, and not the intervention itself.

CONCLUSION

Based on the results of the three RCTs analyzed, it is inconclusive if eccentric training in combination with traditional ACL rehabilitation programs is more effective than traditional ACL rehabilitation programs alone at improving overall knee function in post-ACL reconstruction patients. Kinikli et al. and Papandreou et al. showed statistical significance that the addition of eccentric training was an effective means of ACL rehabilitation based on patient self-reported scales. However, Harput et al. found the addition of eccentric training did not significantly increase overall knee function. Although not proven in this selective EBM review, eccentric exercise has the potential to improve knee stability, overall knee function, and decrease re-injury rates when athletes return to their sport. However, before eccentric exercise could become a standard of ACL rehabilitation, further studies need to be conducted that utilize longer interventions and larger populations. Even with the mixed results gathered from these three studies, it is still promising eccentric training could one day become an integral part of ACL rehabilitation.

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