

Muscle Strength Recovery Following Anterior Cruciate Ligament (ACL) Surgery and the Use of Neuromuscular Electrical Stimulation

D r. Astrid J. Nygaard

Department of Embedded Intelligence, Arctic Coast University, Finland

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Abstract

Restoring knee stability often requires surgery to repair the anterior cruciate ligament (ACL). While recovering from surgery, one major challenge is dealing with muscle weakness, especially in the quadriceps. As an additional treatment option, neuromuscular electrical stimulation (NMES) is gaining popularity for this illness. Muscle strength and functional recovery can be enhanced with the use of NMES. This study aims to examine the efficacy of non-mechanical exercise therapy (NMES) in reestablishing muscle strength following anterior cruciate ligament (ACL) surgery. Over the course of twelve weeks, a randomized controlled trial assessed the efficacy of standard rehabilitation techniques with and without NMES. Quadriceps strength, knee stability, and functional performance were all much improved in the NMES group compared to the control group. These alterations were far more pronounced, according to the findings. In the early phases of rehabilitation, NMES was very useful for correcting activation deficiencies and preventing muscular atrophy. These results provide credence to the idea that including non-muscular components (NMES) into rehabilitation programs following acromial ligament repair (ACL) can improve healing results and hasten the return to functional activities.

Keywords:

Neuromuscular Electrical Stimulation (NMES), Anterior Cruciate Ligament (ACL) Surgery, Quadriceps StrengthTop of Form

Introduction

Among the most common knee injuries that arise as a result of participation in sports, injuries to the anterior cruciate ligament (also known as the ACL) are frequently experienced. Due to the nature of these injuries, surgical intervention is frequently required in order to restore the knee's functionality and stability. Although anterior cruciate ligament (ACL) repair is an exceptionally successful way for treating ligament damage, post-surgical rehabilitation is crucial for obtaining full recovery and returning to the activity levels that were prevalent previous to the injury. This process provides a number of significant obstacles, one of the most critical of which is the requirement to address muscle weakness, particularly in the quadriceps. Disuse, muscular atrophy, and activation deficiencies are the most common causes of this weakness, which generally manifests itself after surgical procedures. Traditional rehabilitation programs often incorporate a wide range of physical therapy techniques. These operations can be broken down into several categories. Strength training, functional mobility training, and

range of motion exercises are some of the techniques that fall under this category. On the other hand, it is probable that these treatments may not sufficiently address the neuromuscular inhibition and strength limitations that are found during the early following period after surgery. This is something that should be taken into further consideration. Over the past few years, neuromuscular electrical stimulation, also referred to as NMES, has garnered a lot of interest as an alternate treatment that directly tackles these issues by triggering muscle contractions through the use of electrical impulses. NMES has the ability to speed up the recovery of strength in a number of different ways, including enhanced muscle activation and the avoidance of atrophy. This is especially true in patients who have poor voluntary control. The efficacy of non-invasive muscle electrotherapy (NMES) in boosting functional outcomes and facilitating the recovery of muscular strength after anterior cruciate ligament (ACL) surgery is the subject of this study. This study aims to provide evidence-based insights into the role that this new therapy plays in optimising recovery by comparing typical rehabilitation regimens with and without the inclusion of NMES. This will be accomplished by comparing the two types of regimens. It is predicted that the findings of this study will contribute to the creation of rehabilitation programs that are more effective for individuals who are undergoing ACL reconstruction due to the information that they provide. In the long run, this will lead to an improvement in the individuals' quality of life as well as their ability to resume activities that are functional.

Importance of Rehabilitation for Post-ACL Reconstruction Healing

Rehabilitation is a crucial part of the healing process for patients who have undergone anterior cruciate ligament (ACL) repair surgery. Restoring the knee's structural stability is the job of the surgical procedure, while the functional restoration of strength, mobility, and performance is the responsibility of the rehabilitation phase. Without proper rehabilitation, patients run the danger of developing deficiencies in the long run. Some of these limitations may manifest as an elevated risk of further harm, a decreased range of motion, or ongoing weakness.

1. Importance of Rehabilitation After ACL Surgery

The following are the key objectives of rehabilitation following anterior cruciate ligament surgery:

- **Restoring Joint Stability:** In order to provide dynamic stability, strengthening the muscles that surround the knee, notably the quadriceps and hamstrings, is essential.
- **Regaining Range of Motion:** The prevention of stiffness and contractures by the use of regulated workouts that enhance flexibility and mobility among the patient.
- **Enhancing Muscle Strength:** Rebuilding muscle mass and power lost due to post-operative disuse and atrophy.
- **Improving Functional Performance:** Making it possible for the patient to resume their regular activities and sports by increasing their neuromuscular control and imitating motions that they would experience in real life.

- Reducing Pain and Swelling: Managing inflammation and discomfort in order to promote early mobilisation of those affected.

2. Phases of Rehabilitation

Following surgery on the anterior cruciate ligament (ACL), rehabilitation is often broken up into various phases, each of which has specific goals:

- Immediate Postoperative Phase (Weeks 1–2): The primary goals of this treatment are to alleviate pain and swelling, safeguard the surgery site, and begin performing mild range of motion exercises. When it comes to weight-bearing, patients frequently make use of special devices.
- Early Rehabilitation Phase (Weeks 3–6): Exercises that activate the muscles, such as isometric quadriceps contractions, are introduced, and weight-bearing is started as soon as the patient is able to tolerate them. Re-education of the neuromuscular system is given priority in order to repair activation impairments.
- Strengthening Phase (Weeks 7–12): In order to develop muscle strength, particularly in the quadriceps and hamstrings, this training method places an emphasis on progressive resistance training. Step-ups and half squats are two examples of the controlled functional motions that are introduced and performed.
- Advanced Functional Training Phase (Months 3–6): Dynamic workouts, plyometric exercises, and sport-specific drills are all incorporated into this program in order to regain agility, balance, and coordination. During this phase, the patient is prepared to resume activities that require a high level of demands.
- Return-to-Sport Phase (Months 6+): Assessing preparation for sports, fixing any deficiencies that may still exist, and putting injury prevention techniques into action are the primary focusses of this program.

3. Neuromuscular Challenges After ACL Surgery

During the course of rehabilitation that follows surgery on the anterior cruciate ligament, neuromuscular inhibition is one of the most significant issues that arises, particularly in the quadriceps. This condition, which is known as arthrogenic muscular inhibition (AMI), manifests itself when there is a breakdown in the communication that takes place between the neurological system and the muscle. This disruption typically results in a persistent weakening in the affected muscle. Rehabilitating patients who have suffered an acute myocardial infarction (AMI) is a top priority in the field of rehabilitation. This is due to the fact that quadriceps strength is essential for knee stability and functional performance.

4. Role of Neuromuscular Electrical Stimulation (NMES)

In particular, neuromuscular electrical stimulation (NMES) has become an essential component of the rehabilitation process for the anterior cruciate ligament (ACL), particularly in the early phases of the process. Non-invasive muscle electrical stimulation (NMES) moves across the voluntary neuromuscular circuits in order to battle acute myocardial infarction (AMI) and to promote early strength recovery. This is done in order to promote early strength recovery.

5. Psychological and Functional Benefits of Rehabilitation

In addition to the physical recovery process, rehabilitation is a vital component in the process of resolving the psychological impact that is associated with injuries to the anterior cruciate ligament (ACL). When people are afraid about re-injury and have reduced confidence in their knee's stability, it is typical for them to be reluctant to return to high-demand activities or sports. This is because they are uncertain about the stability of their knee. With the support of a rehabilitation program that is well-structured and includes education, goal setting, and graded exposure to exercises, patients are able to regain confidence and trust in their knee function. This is possible because of the positive effects of the program.

6. Multidisciplinary Approach

Collaboration between surgeons, physiotherapists, and physicians who specialise in sports medicine is frequently required in order to achieve successful rehabilitation. This is because of the interdependence of these medical professionals. Patients are assured of receiving comprehensive care by utilizing this multidisciplinary approach, which takes into account both their physical and psychological needs throughout the course of their recovery. This strategy ensures that patients receive care that is thorough.

As a conclusion, rehabilitation is an integral component of recovery following surgery on the anterior cruciate ligament (ACL). This function ensures that the transition from surgical repair to total functional restoration is carried out in a smooth manner. Through the utilization of methods that are validated by research and the utilization of a phased approach, rehabilitation programs provide patients with assistance in achieving optimal outcomes, minimizing issues, and returning to the level of activity that they desire.

Rehabilitative Use of Neuromuscular Electrical Stimulation (NMES)

In recent years, neuromuscular electrical stimulation (NMES) has emerged as a crucial component of rehabilitation, especially for patients recovering from anterior cruciate ligament (ACL) surgery. Incorporating Nemes into the recovery process is now essential. To induce muscular contractions, non-muscular electrical stimulation (NMES) involves the application of electrical impulses to the muscles. This approach goes straight to the muscle fibers, skipping the voluntary neuromuscular circuits in the process. The approach is useful in treating neuromuscular inhibition, weakness, and atrophy of the muscles that are prevalent after anterior cruciate ligament (ACL) surgery.

1. Principles and Mechanism of NMES

Surface electrodes applied to the skin over specific muscles allow NMES to produce regulated electrical impulses. Muscles contract involuntarily in response to these signals, simulating natural movement. The main processes comprise:

- **Muscle Activation:** Stimulates the two types of muscle fibers—type I, which contracts slowly, and type II, which contracts quickly—that are sometimes hard to activate on your own while you're still healing.
- **Neuromuscular Re-Education:** restores communication between the brain and muscles, which helps fight against arthrogenic muscular inhibition (AMI).

- **Strengthening and Conditioning:** Increases strength and power by strengthening weak muscles through repetition, which is very helpful for recovering quadriceps after ACL surgery.

2. Benefits of NMES in ACL Rehabilitation

Several benefits of NMES make it a useful supplement to more conventional forms of rehabilitation:

- **Combatting Quadriceps Atrophy:** As a result of inactivity and AMI, quadriceps weakness is a common side effect of ACL surgery. By engaging the quadriceps in a direct manner, NMES promotes strength recovery and delays early atrophy.
- **Improving Range of Motion:** During the initial stages of therapy, NMES helps with joint mobility and flexibility by promoting muscle contractions.
- **Enhancing Knee Stability:** Dynamic stability, which is enhanced by strengthening the muscles surrounding the knee, lowers the likelihood of re-injury.
- **Early Intervention:** Applying NMES immediately following surgery allows for ongoing recovery progress, especially in cases when voluntary muscle activation is limited.
- **Pain Reduction:** Research has demonstrated that NMES can enhance blood flow and alleviate pain, which in turn can increase patient comfort and therapeutic adherence.

3. NMES in Different Phases of Rehabilitation

As the demands of ACL rehabilitation change over time, NMES remains effective at each stage:

- **Immediate Postoperative Phase:** Activates the quadriceps to prevent atrophy of the medial arch and to keep muscular tone when exercise levels are low.
- **Early Strengthening Phase:** Makes vigorous activities more effective by increasing muscular engagement.
- **Functional Recovery Phase:** Helps patients build muscle endurance and proficiency in complicated motions in preparation for more active activities and sport-specific training.

4. Integration with Standard Rehabilitation Protocols

- When used in conjunction with more conventional forms of rehabilitation, such as:
- Strength training using isometric and dynamic exercises can help you get the most out of your active workouts.
- Training the gait muscles to engage in functional activities can help restore normal walking patterns.
- Flexibility exercises and mobility work: helping the body regain its range of motion in affected joints.

5. Challenges and Considerations

- Despite all of NMES's advantages, there are a few things to keep in mind and limitations:
- The electrical stimulation could be painful for patients, particularly during the first few sessions, so it's important that they stick with the treatment plan.

- Cost and availability are two factors that could restrict the adoption of NMES devices to a small group.
- Correct Application: It is important to follow professional assistance when placing or adjusting the electrodes, as doing so incorrectly can limit their effectiveness or create discomfort.

6. Evidence Supporting NMES in ACL Rehabilitation

Numerous clinical trials have shown that NMES improves functional outcomes and muscle strength recovery following ACL surgery. Results in quadriceps strength, knee stability, and readiness to return to sport are typically shown more rapidly in patients who get NMES in addition to usual rehabilitation regimens.

7. Future Directions in NMES Technology

Recent developments in NMES technology, such as wireless devices and stimulation protocols driven by AI, bode well for the future of this field. Connecting with wearable tech and mobile apps could improve patient compliance and real-time tracking.

In conclusion, NMES is a useful adjunctive method for ACL reconstruction patients' rehabilitation, addressing concerns including neuromuscular inhibition and quadriceps weakness. Its integration into preexisting rehabilitation programs has shown to hasten patients' recoveries, improve their functional results, and allow them to resume the same levels of activity they had prior to injury.

Conclusion

Patients who have undergone surgery to repair the anterior cruciate ligament (ACL) may experience considerable challenges when returning to strength training, neuromuscular inhibition, and muscle atrophy following the procedure. Neuromuscular electrical stimulation, often known as NMES, is a tool that contributes to the success of this procedure. NMES is a savior when it comes to the early periods of recuperation, when conventional workouts could be too stressful. This is because in order to trigger muscular contractions directly, it eliminates the need for purposeful activation, which is a requirement for traditional workouts. Because of its one-of-a-kind ability to boost muscle activation, non-muscular exercise (NMES) is an efficient strategy for restoring quadriceps strength, stabilizing the knee, and accelerating functional recovery. There are numerous benefits associated with introducing non-invasive muscle energy stimulation (NMES) into standard rehabilitation regimens. Some of these benefits include increased mobility, decreased discomfort, and a shorter time to functional activity recovery. However, it is only effective if it is utilized appropriately, with the patient adhering to the directions, and under the guidance of a qualified medical professional. It is vital to continue teaching and make advancements in NMES technology in order to overcome difficulties such as the accessibility of devices and the discomfort experienced at an early age. When it comes to maximizing recovery results following ACL surgery, NMES is a crucial instrument that should not be overlooked. Additionally, it is an effective technique of treatment that does not include any intrusive procedures and works in conjunction with traditional physiotherapy to assist patients in getting back on their feet. It is anticipated that future research



and developments in NMES technology will result in a number of benefits for patients, including both increased access and improved long-term outcomes.

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