

The Impact of Postoperative Neuromuscular Electric Stimulation (NMES) after Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-analysis of Randomized Controlled Trials

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INTRODUCTION:

Arthrogenic muscle inhibition (AMI) of the quadriceps poses a significant challenge after ACL injury and surgery. Neuromuscular electrical stimulation (NMES) is a therapeutic modality which is increasingly used as an adjunct to standard rehabilitation to treat AMI. This study aims to determine the effectiveness of NMES on quadriceps strength and knee function after ACL surgery.

METHODS:

An English-language search of PubMed, Ovid MEDLINE, and Embase from inception until January 2025 was conducted. Inclusion criteria was defined as randomized controlled trials (RCTs) on adults undergoing ACL surgery with NMES as an intervention and standard rehabilitation as a control. Data was collected on the patient demographics, treatment parameters, and clinical outcomes including knee extension and flexion strength, thigh circumference, pain, and functional scores. Meta-analysis of outcomes was performed with subgroups including early- (≤ 12 weeks) or late- (>12 weeks) postoperative follow-up. Quality of the included studies was assessed according to the Cochrane collaboration risk-of-bias tool.

RESULTS:

Twenty-two RCT studies met our inclusion criteria ($n=714$). The frequency weighted mean age of included patients across all studies was 27.0 years, and mean follow-up time was 18.4 weeks (4-54). Twelve studies were included in pooled analysis for isometric knee extension strength and demonstrated statistically significant improvements in absolute strength between NMES and control groups ($n=109$, MD 0.24; 95%CI 0.2-0.27; $p<0.01$, $I^2 = 9\%$) and strength as a percentage of the uninjured limb ($n=264$, SMD 0.87; 95%CI 0.11-1.64; $p=0.03$, $I^2 = 87\%$) in the early- but not late-postoperative follow-up. Similar statistical significance was noted with improvements in knee flexion ($p=0.01$, thigh circumference ($p=0.04$) and Lysholm scores ($p=0.02$) but not IKDC scores. Four studies reporting isokinetic muscle strength were pooled, and no statistically significant difference was found.

DISCUSSION AND CONCLUSION:

Patients treated with NMES as an adjunct to postoperative rehabilitation after ACLR surgery had significant improvements in isometric knee extension strength in the early post-operative period (6 to 12 weeks) but not in the late postoperative period (>12 weeks). Given the fewer number of studies and patients with available data beyond the 12 week mark, the likely explanation for this finding is that this analysis was underpowered. Another contributing factor may be that treatment with NMES most often started within the first two weeks postoperatively, and lasted for a mean of 5.76 weeks leading to early differences that were not sustained. It is plausible that longer term use can lead to more sustained results, which may be a direction of future research. Studies that employed functional electric stimulation demonstrated more sustained outcomes.

CONCLUSION

Compared with standard rehabilitation, the use of NMES as an adjunct in ACLR rehabilitation accelerates early recovery of isometric knee extension and flexion strength. While the extent of improvements in knee strength or functional recovery beyond the three-month postoperative period remains uncertain, the use of NMES alongside functional rehabilitation may confer sustained benefits.

