Keele UNIVERSITY

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Impact Accelerator Unit

Keele Critically Appraised Topic Form

Clinical Question:
In adults, is the addition of neuromuscular electrical stimulation to quadriceps post Total Knee Replacement (TKR) more effective than usual care in improving pain, quadriceps strength and function?

Clinical bottom line

There is no good quality evidence to support use of neuromuscular electrical stimulation to improve quadriceps muscle strength following total knee arthroplasty, it was unclear whether the intervention was delivered as an inpatient or an outpatient. No evidence on pain and functional outcomes. Protocol and parameters of NMES need to be investigated with further research.

Plain language summary

There is no good quality evidence to support the use of electrical stimulation pads applied to the front thigh muscles after a person has had a knee replacement, we cannot say whether the electrical stimulation helps strength, pain or the ability to be active. It was also not clear whether the people were treated whilst still in hospital or after their discharge home. Future audit would be challenging as no agreed standard on how electrical stimulation should be used. Further research into this type of stimulation is needed.

Why is this important?

Total knee arthroplasty/replacement (TKA/TKR) is a common surgical intervention for end stage management of osteoarthritis of the knee (Price et al, 2018). Following TKA it has been observed that some patients have poor quadriceps activation, control and strength which impedes early function. The literature has termed this ‘arthrogenic muscle inhibition’ (AMI) (Stevens et al, 2003 & Mizner et al, 2005). AMI is indicated by loss of strength and the inability to activate the quadriceps voluntarily. It is thought that this is due to alterations of the sensory and motor pathways responsible for the modulation of quadriceps activation (Rice *et al*, 2010).
Patients with AMI could benefit from muscular stimulation to support the usual strengthening exercises provided and optimise post-operative recovery. Neuromuscular electrical stimulation (NMES) may be helpful in overcoming patients’ inability to voluntarily activate muscles by means of externally elicited muscle contractions (Maffiuletti, 2010).

Electrical stimulation is widely used in neurological physiotherapy settings to aid function. Post operatively, if quadriceps are delayed in activation then other factors such as the patients swelling; pain and confidence in mobilising may be impacted. Improving functional outcomes for patients following TKA includes: potential reduction in post op appointments; reduced analgesia requirements; reduced post-operative deep vein thrombosis risk; and reduce falls risk. NMES could be helpful in outpatient physiotherapy setting for some TKA patients who struggle to hit normal rehabilitation

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targets. NICE states rehabilitation should be focussed on those individuals who have ongoing functional impairment or are not meeting their rehabilitation goals however NICE does not comment on NMES as a modality. (NICE 1.10.5, 2020).

Search timeframe (e.g. 2009-2024)

10 years+, all available

Search Criteria

	Description	Search terms
Population and Setting	Adults who have undergone total knee replacement	Total knee replacement. Total knee arthroplasty. Knee joint replacement. TKR. TKA.
Intervention or Exposure	Neuromuscular electrical stimulation for quadriceps recruitment.	Electrical stimulation. Neuromuscular electrical stimulation. NMES.
Comparison, if any	Usual care - Physiotherapy exercises, advice and education	Standard care. Usual care. Physiotherapy. Physical therapy. Physical therapy modalities. Patient advice. Patient education. Exercise therapy. Therapeutic exercise. Exercise. Quadriceps exercises
Outcomes of interest	Pain reduction Lower limb function Quadriceps strength	Treatment outcomes. Improved patient outcomes. Pain management. Improved pain control. Quadriceps activation. Quadriceps muscle. Quadriceps strengthening. Quality of life. Oxford knee score. Knee score Koos pain and function. Koos outcomes measures. Activator appliances

Types of studies	Systematic reviews, meta-analysis, randomised controlled trial, clinical trial, journal articles.	

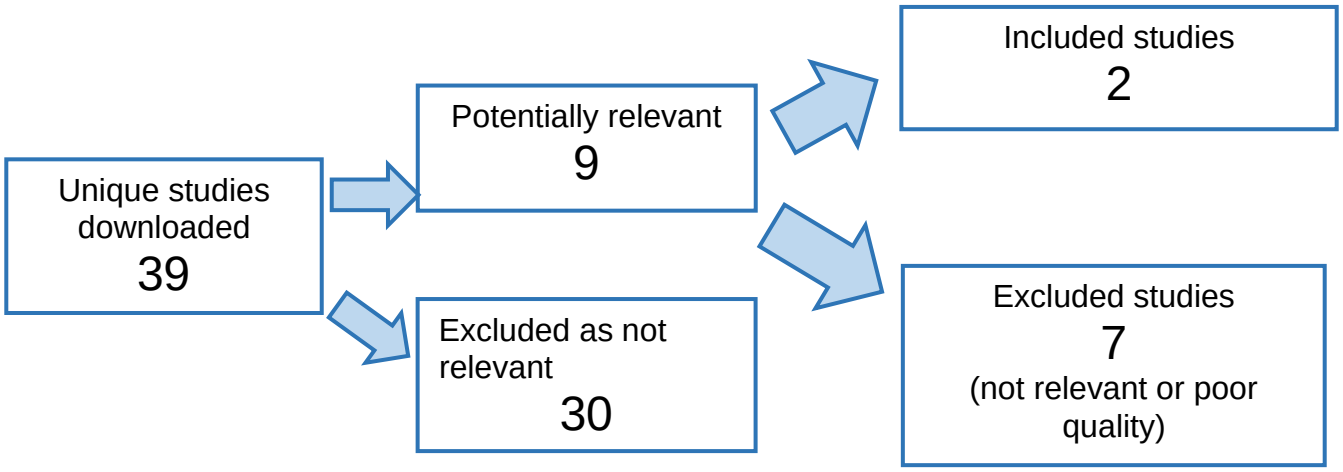
Databases Searched

The Cochrane Library, Medline, Cinahl, Emcare, Embase, Trip, Epistemonikos, Google Scholar.

Date of search

Requested on 22nd June 2023. Completion on 30th June 2023.

Results of the search



There were 39 unique downloaded studies. There were 9 potentially relevant studies. There were 2 included and their critical appraisal is included in Table 1. There were 37 excluded studies.

Table 1- Detail of included studies

For further information regarding I^2 and heterogeneity please see appendix 1.

First Author, year, and type of study	Population and setting	Intervention or exposure tested	Study results	Assessment of quality and comments
Peng et al, 2021. Systematic review and meta-analysis.	Adults (age 65-79) Post TKR and received post-operative NMES.	Subjects underwent a form of NMES post-operatively alongside conventional physiotherapy. The	▪Quadriceps muscle strength favoured NMES at: <1 month (I^2=0%, 187pts) 1-2 months (I^2=7%, 99pts) 3-4 months (I^2=0% 267pts) and	Focused population, intervention and outcome. Included studies were appropriate to answer the studies title question. Publications in English language.

	Included studies from UK, Greece, Spain, Japan, USA, and Turkey. 9 RCT studies included in meta-analysis, with total of 691 subjects.	comparator was conventional physiotherapy / exercises. The delivery of NMES varied in type (sensory or motor); intervention frequency; duration and timescale of treatment between all 9 studies. Outcome measures were: Quadriceps muscle strength, pain, WOMAC, Timed up and go test, stair-climbing test, 3 & 6 minute's walk tests, knee flexion, knee extension, and SF-36.	12-13months (I^2=0%, 204 pts) (total of 4 studies) ▪ Pain levels favoured NMES group at: 1-2 months (I^2 50%, 244 pts, 4 studies) and at: 3-6 months (I^2 33%, 413 pts, 5 studies). No difference between groups at <1month and >6 months. ▪ WOMAC favoured NMES at 3-4 months only (I^2 0%, 2 studies, 107 subjects) ▪ Timed up and go favoured NMES only at <1month, I^2 0%. (2 studies, 147 subjects). Other timescales had high heterogeneity. ▪ 3-minute walk test favoured NMES groups at 6 weeks (1 study, 70 subjects) and 3-6months (I^2 0%, 2 studies, 100 subjects) ▪ Stair climbing and 6-minute walk showed no difference and had high heterogeneity. ▪ Knee flexion, knee extension and SF-36 had no difference.	Two authors assessed the studies used the Cochrane bias assessment tool, a third author helped with any disagreements. Bias in each domain was documented for each paper. Performance bias of studies included. Significant heterogeneity was seen across the included RCTs methodology, including NMES type, dosage and duration as well as outcomes. Given this information it was unclear why authors went ahead and did meta-analysis. Results were displayed using forest plots, heterogeneity calculations and confidence intervals. Very small numbers of subjects in included RCT's. Limitations were not stated. No comments regarding adverse events or cost calculations.

Labanca et al,2022 Systematic Review	Adults who have undergone TKR and received NMES post operatively. 4 included RCT studies were from USA and Japan, with a total of 478 subjects	Subjects underwent a form of NMES post-operatively alongside conventional physiotherapy. The comparator was conventional physiotherapy / exercises. One study had a third group doing resistance training. The delivery of NMES varied in intervention type; frequency; duration and timescale of treatment. Outcome measure was quadriceps muscle strength.	Quadriceps strength was measured as a maximum isometric voluntary contraction. Results were expressed as a percentage increase in quadriceps strength at variable time intervals post operatively. Short term (2-6 weeks), midterm (3 months), and long term (12 months). ▪ The NMES group (both motor and sensory) had greater increase in quadriceps strength between 2 and 6 weeks, than the control group. ▪ The control group had an initial decline in strength which the NMES group did not. ▪ Long term the NMES group had higher quadriceps strength than the controls.	Clear question with focused population, intervention and outcome. All included studies were relevant; however they did not search for studies on Medline; Embase; Pedro or Cinahl. Cochrane risk of bias tool was utilised. Three authors reviewed the papers, a fourth was used for disagreements. Heterogeneity was seen across the included RCT's methodology including NMES type, dosage and duration as well as outcomes. Meta-analysis was not carried out due to high heterogeneity. Study limitations were stated. Benefits are reported clearly, no record of harm reported, no cost benefit analysis conducted.

Summary

The RCT's used within the above reviews vary in NMES application, timescale of application and timescale of onset post TKR, study power, outcome measures used and method of measuring strength. Despite this, the patients who received NMES had positive effects, but these were not significant enough to support clinical recommendations.

It is unclear whether the positive results are clinically meaningful or significant and the placebo has not been considered. Neither paper made comments on adverse effects or harm. The authors of this CAT consider this a low-risk procedure and so are not concerned by this omission. No cost benefit analysis was done by neither Peng et al (2021) or Labanca et al (2022).

Limitations identified were that only two included RCT studies included long term follow up, also only three of the studies described the standard rehabilitation utilised. Peng et al (2021) failed to mention limitations.

Regarding quadriceps strength. Both reviews used the same four RCT's to analyse the effect on quadriceps strength. The RCT's had small numbers with 2 papers using only 22-24 subjects per treatment arm, one with 35 subjects per arm and the remaining RCT with 100 subjects per arm. The high level of methodological heterogeneity resulted in Labanca using a narrative synthesis instead of meta-analysis. Thus, the meta-analysis by Peng should be interpreted with caution due to the methodological heterogeneity and poor overall numbers of subjects in each arm.

Regarding pain, Peng et al (2021) considered it as an outcome, however the high heterogeneity of the data is concerning and should be interpreted with caution.

Only Peng (2021) considered functional outcome measures. Although low heterogeneity is positive, care should be used when interpreting the functional outcomes due to the very low numbers of subjects involved (see table above).

Implications for Practice/research

We are unable to recommend a protocol or parameters that are best post TKR due to: the variation in study methodology; the lack in power; and the moderate heterogeneity of results. There is lack of understanding why NMES may provide a benefit without clear protocol or delivery dosage.

Further research is needed which includes identifying an optimum protocol for use in clinical practice. Higher quality RCT's with larger numbers of subjects per treatment arm; control groups with minimised placebo effect; functional and pain outcomes included and longer term follow up are required.

Unfortunately, no cost benefit analysis was conducted in the studies found. Failure to include these plus the inability to recommend a protocol means developing a business case or audit for the use of NMES within UK care systems will be very challenging until further research is published.

What would you post on X (previously twitter)? (280 characters MAX)

Neuromuscular stimulation to quadriceps muscle following total knee replacement has no good quality evidence to improve strength, pain or function. More high quality research is required.
(188 characters)

References

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Price AJ, Alvand A, Troelsen A, Katz JN, Hooper G, Gray A, et al. Knee replacement. Lancet 2018; 392:1672–82.

Rice DA, McNair PJ. Quadriceps arthrogenic muscle inhibition: neural mechanisms and treatment perspectives. Semin Arthritis Rheum 2010; 40:250–266.

Stevens JE, Mizner RL, Snyder-Mackler L. Quadriceps strength and volitional activation before and after total knee arthroplasty for osteoarthritis. J Orthop Res 2003; 21:775–779.

Appendix 1.

Heterogeneity

Cochrane states “Any kind of variability among studies in a systematic review may be termed heterogeneity. It can be helpful to distinguish between different types of heterogeneity. Variability in the participants, interventions and outcomes studied may be described as clinical diversity (sometimes called clinical heterogeneity), and variability in study design and risk of bias may be described as methodological diversity (sometimes called methodological heterogeneity). Variability in the intervention effects being evaluated in the different studies is known as statistical heterogeneity, and is a consequence of clinical or methodological diversity, or both, among the studies. Statistical heterogeneity manifests itself in the observed intervention effects being more different from each other than one would expect due to random error (chance) alone. We will follow convention and refer to statistical heterogeneity simply as heterogeneity” (Cochrane, 2011)

The I^2 statistic describes the percentage of variation across studies that is due to heterogeniety rather than chance (Higgins and Thompson, 2002). Thresholds for the interpretation of I2 can be misleading, since the importance of inconsistency depends on several factors. A rough guide to interpretation is as follows:

- 0% to 40%: might not be important;
- 30% to 60%: may represent moderate heterogeneity*;
- 50% to 90%: may represent substantial heterogeneity*;
- 75% to 100%: considerable heterogeneity*.