BS Structured Summary

Article: Arthrogenic muscle inhibition after ACL reconstruction: a scoping review of the efficacy of interventions.

Structured Summary of the Scoping Review: Arthrogenic Muscle Inhibition After ACL Reconstruction

Original Article: Correction: Arthrogenic muscle inhibition after ACL reconstruction: a scoping review of the efficacy of interventions

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Study Objective

The primary objective of this scoping review was to systematically determine the efficacy of various reported therapeutic interventions aimed at mitigating Arthrogenic Muscle Inhibition (AMI). Specifically, the authors sought to evaluate whether these interventions effectively improve quadriceps activation failure—a critical barrier to rehabilitation—in patients following Anterior Cruciate Ligament (ACL) injuries or reconstruction, compared to standard therapy or control groups.

Main Methodology

This study employed a **scoping review** design, following the five-stage methodological framework established by Arksey and O'Malley, and adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This approach was chosen due to the exploratory nature of the research question and the emerging evidence base surrounding AMI treatment.

Data Sources and Search Strategy: The literature search was conducted across three major databases: PubMed, EMBASE, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL). Search terms were comprehensive, combining concepts such as 'arthrogenic muscle inhibition,' 'quadriceps activation,' 'anterior cruciate,' 'corticomotor,' and 'neuroplasticity.'.

Eligibility Criteria: The review included original research articles evaluating the efficacy of therapeutic interventions for AMI, focusing primarily on patients with ACL injury or reconstruction. Recognizing the limited evidence,

studies involving acute knee pathologies (e.g., meniscal injury, patellofemoral instability) or laboratory studies using artificially induced knee effusions in young patients were also included to broaden the scope. Exclusions comprised isolated case reports, and studies involving patients with chronic conditions (e.g., osteoarthritis) or major trauma (e.g., multiligament injury).

Data Extraction and Quality Assessment: Data extraction focused on study design, participant characteristics, intervention type, outcome measures (e.g., Central Activation Ratio (CAR), Maximal Voluntary Isometric Contraction (MVIC), H-reflex amplitude), and findings.

The methodological quality and risk of bias for individual studies were assessed using the Physiotherapy Evidence Database (PEDro) criteria. The overall quality of evidence for each therapeutic intervention was then assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, which classifies evidence quality as High, Moderate, Low, or Very Low.

Key Results

The initial search yielded 780 potential articles, of which 20 met the final inclusion criteria. These studies provided evidence across several intervention categories targeting AMI.

1. **Cryotherapy**

- **Evidence Quality:** Moderate (GRADE assessment).
- **Findings:** Four studies, including three Randomized Controlled Trials (RCTs), consistently demonstrated that cryotherapy was associated with significant improvements in AMI features. Effect sizes were reported as "very large." Specific improvements included increased quadriceps strength (MVIC) and enhanced quadriceps motor neuron pool recruitment (H-reflex).

2. **Physical Exercises**

- **Evidence Quality:** Moderate (GRADE assessment).
- **Findings:** our studies evaluated exercise efficacy. All demonstrated significant improvement in quadriceps activation (MVIC and CAR).

  Traditional rehabilitation programs involving open-chain exercises with resistance and progressive closed-chain strengthening were effective.

  One study highlighted the specific benefit of a **hamstring fatigue exercise protocol**, showing a significantly higher quadriceps CAR post-fatigue compared to pre-fatigue in the ACLR group. This

suggests that altering the afferent input or spinal reflex excitability through specific fatigue protocols may transiently bypass inhibition.

3. **Neuromuscular Electrical Stimulation (NMES)**
- **Evidence Quality:** Low (GRADE assessment).
- **Findings:** The evidence for NMES was mixed and of lower quality. While one study suggested that combining NMES with eccentric exercise helped restore biomechanical limb symmetry, NMES alone did not offer an advantage over standard care in improving quadriceps strength or activation (MVIC). Eccentric exercise alone proved superior to NMES alone in recovering quadriceps strength.

4. **Transcutaneous Electrical Nerve Stimulation (TENS)**
- **Evidence Quality:** Low (GRADE assessment).
- **Findings:** TENS was evaluated in two studies, both showing limited efficacy. While one study reported a transient increase in quadriceps MVIC immediately post-TENS, the effect was inconsistent across studies and generally not sustained.

5. **Other Interventions (Ultrasound and Vibration)**
- **Evidence Quality:** Very Low (GRADE assessment).
- **Findings:** Interventions such as therapeutic ultrasound and vibration therapy showed very limited or no robust evidence of efficacy in improving quadriceps activation failure

Conclusions and Clinical Implications

Conclusions

This scoping review concludes that there is **moderate-quality evidence** supporting the efficacy of **cryotherapy** and **physical exercises** in successfully managing and improving quadriceps activation failure resulting from Arthrogenic Muscle Inhibition following ACL injury and reconstruction. Evidence supporting other modalities, such as NMES and TENS, is of lower quality, while evidence for ultrasound and vibration is very low.

Clinical Implications

For orthopedic surgeons and rehabilitation specialists, the findings provide clear, evidence-based recommendations for the early phase of post-ACLR rehabilitation:

1. **Prioritize Cryotherapy and Exercise:** Given the moderate quality of evidence, cryotherapy and structured physical exercises should be considered foundational components of the early post-operative

regimen to directly combat AMI. Cryotherapy likely acts by reducing joint swelling, pain, and inflammatory afferent input, thereby lowering neural inhibition.

2. **Exercise Specificity:** The inclusion of exercises designed to temporarily alter afferent feedback, such as hamstring fatigue protocols, warrants further investigation but shows promise as a method to acutely enhance central quadriceps activation (CAR).

3. **Cautious Use of Electrotherapy:** While NMES and TENS are frequently used, the evidence suggests they may not be superior to—or even as effective as—standard or eccentric exercise alone in restoring quadriceps strength and activation. If used, NMES should ideally be combined with active exercise (e.g., eccentric loading) rather than used as a standalone modality to maximize potential benefits in restoring functional symmetry.

4. **Focus on Neural Mechanisms:** The review underscores that AMI is a neurally mediated phenomenon involving altered spinal and cortical processing. Effective interventions must target these inhibitory pathways, either peripherally (reducing joint effusion/pain via cryotherapy) or centrally (through intense, targeted exercise that promotes motor unit recruitment).

5. **Need for High-Quality Research:** The overall low quality of evidence for several common modalities (NMES, TENS) highlights the need for more rigorously designed, adequately powered RCTs, particularly those focusing on long-term outcomes and utilizing objective measures of central activation (CAR) rather than solely relying on MVIC.

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