MEDICINE & PUBLIC HEALTH
e-ISSN 2956-9443

2025, Vol. 3, No. 2

DOI: 10.31749/MandPH-AFMKU-25-2-004
Received: 2025-12-17
Accepted: 2026-01-19

REVIEW PAPER / META-ANALYSIS

Prehabilitation before total knee arthroplasty (TKA): A literature review and proposed methods for increasing its effectiveness

Daria Chekina [A–F]

Department of Physiotherapy, Faculty of Health Sciences, Medical College, Andrzej Frycz Modrzewski Krakow University, Poland

A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Abstract

Prehabilitation, understood as a targeted physiotherapeutic and educational intervention conducted before total knee arthroplasty (TKA), is becoming increasingly popular as a method of improving postoperative outcomes. The aim of this study is to analyze contemporary research on the effectiveness of prehabilitation in patients preparing for TKA, with particular focus on physical function, pain, and length of hospital stay, as well as to explore ways to enhance the effectiveness of prehabilitation programmes. The review includes one experimental study and one systematic review, covering a total of over 1,600 patients. The results suggest that prehabilitation programmes may shorten the hospital stay and reduce preoperative pain, whereas their effect on long-term function and muscle strength remains less clear. Further research is needed to optimize prehabilitation programmes and definitively determine their efficacy.

Keywords: total knee arthroplasty, neuromuscular electrical stimulation, prehabilitation, blood flow restriction training, motor imagery

Introduction

Total knee arthroplasty (TKA) is one of the most commonly performed orthopaedic procedures. Many patients experience muscle weakness, a reduced range of motion (ROM), and pain prior to surgery, which can prolong the recovery and return to functional activities. Prehabilitation aims to prepare patients through strengthening exercises, improvement of endurance and muscle flexibility, and health education. The goal is to shorten the hospital stay, improve physical function, and enhance patient comfort following TKA. Additionally, this study aims to identify and discuss methods that could potentially increase the effectiveness of prehabilitation programmes.

✉ Daria Chekina, e-mail: dariiachekina@gmail.com

Methods

Two main sources were analyzed: a randomized clinical trial [1] and a systematic review of 22 randomized controlled trials (RCTs) involving patients preparing for TKA [2]. Characteristics of participants, types of prehabilitation programmes, duration of interventions, and outcomes related to function, pain, ROM, and length of hospital stay (LOS) were evaluated.

Results

Prehabilitation Programmes

Studies employed multimodal interventions.

Strength exercises: knee extensions, bridges, squats, leg press; goal: to increase lower limb muscle strength.

Aerobic training: treadmill walking, stationary cycling, stepper; goal: to improve cardiovascular endurance.

ROM and flexibility exercises: heel slides, AROM, PROM, stretching of hip flexors and calves; goal: to maintain a ROM and prevent contractures.

Balance and motor control training: single-leg stance (SLS), weight shifting, multi-directional walking; goal: to improve neuromuscular control.

Patient education and supportive techniques: HEP, neuromuscular electrical stimulation (NMES), massage, mobilization, heat/cold therapy; goal: to reduce preoperative pain and stress.

Study Characteristics

Experimental study [1]: 45 patients; intervention: prehabilitation + education vs. education only; duration: 4–6 weeks. Results: small, statistically non-significant improvements in function (Chair Stand Test) and KOOS-ADL.

Systematic review [2]: 1,601 patients; home-based or outpatient programmes; duration: 4–12 weeks; compliance ~90%. Results: significant reduction in LOS (MD − 0.43 days), decreased preoperative pain; no significant changes in long-term function and muscle strength.

Proposals to Enhance Prehabilitation Effectiveness

This study evaluates that, to enhance the effect of prehabilitation before TKA, it is reasonable to incorporate NMES in addition to conventional exercises. NMES is a method in which electrical impulses induce muscle contraction, activating both peripheral muscle fibres and central motor pathways. A systematic review and meta-analysis [3] demonstrated that postoperative NMES improves quadriceps strength: standardized mean difference (SMD) was 0.81 at 1 month, 0.55 at 1–2 months, 0.42 at 3–4 months, and 0.46 at 12–13 months after TKA. NMES also showed moderate effects on pain and function (Timed Up and Go [TUG] test: −2.23 s; 3MWT: +28.35 m). Based on these data, it can be hypothesized that adapting NMES to the preoperative period may also yield positive effects. The present study proposes that high-intensity preoperative NMES could additionally reduce quadriceps atrophy, improve neuromuscular activation, and accelerate post-TKA strength recovery. This effect may be explained by a larger muscle fibre reserve, lower relative functional loss, "motor memory", and enhanced central motor activation, the muscle "wakes up" faster after surgery and recruits motor units more easily.

Furthermore, to increase prehabilitation effectiveness, blood flow restriction training (BFRT) can be considered. BFRT may be particularly effective as a component of prehabilitation before TKA. BFRT involves performing low-load exercises while partially occluding arterial inflow and venous outflow to the targeted limb, creating a localized hypoxic and metabolic stress environment that promotes anabolic signaling pathways responsible for muscle hypertrophy and strength gains at relatively low mechanical loads. According to current evidence specific to knee arthroplasty [4], prehabilitation programmes incorporating BFRT for 4–8 weeks before surgery have demonstrated significant improvements in muscle strength and functional outcomes, with some RCTs reporting greater gains in knee extensor and leg press strength, as well as enhanced early recovery of physical performance when compared to usual care without structured preoperative interventions. Mechanistically, BFRT stimulates metabolic stress and growth factor production (e.g., IGF-1, GH), while also activating vasoactive metabolites and the vascular endothelial growth factor, which may enhance local angiogenesis and increase post-occlusion blood flow, contributing to improved tissue perfusion, muscle adaptation, and functional reserve prior to TKA. These effects are achieved with much lower joint loading than traditional high-intensity resistance training, making BFRT particularly suitable for patients with painful or functionally limited knees who are unable to tolerate heavy mechanical stress during prehabilitation.

Another study demonstrates clinical data on the effectiveness of BFRT in the context of TKA: a 6-week prehabilitation programme with BFRT (cycling exercises, twice weekly, cuff pressure at 40% of individual occlusion limit) was conducted on 30 patients [5]. Post-prehabilitation, quadriceps strength increased by approximately 170% (compared to ~91% in an active control group), and thigh circumference (muscle mass indicator) increased by ~7% ($p < 0.05$). Postoperatively, patients maintained benefits: thigh circumference remained above baseline, and several KOOS domains improved significantly more than controls. Thus, I hypothesize that preoperative BFRT of an appropriate intensity may limit quadriceps atrophy preoperatively, stimulate neuromuscular activation, increase the muscle fibre reserve and facilitate faster strength recovery after TKA. Although direct mechanistic data (e.g., cellular changes, fibre type, motor activation) for TKA are limited, Erickson's protocol shows that BFRT may influence both strength and muscle morphology, and knee biomechanics. Inclusion of BFRT in prehabilitation could provide additional adaptive stimuli and contribute to better postoperative outcomes.

It can also be considered reasonable to include neurorehabilitation techniques, such as motor imagery (MI) and action observation (AO), in the prehabilitation protocols. These methods rely on mirror neuron activation and are promising complements to TKA prehabilitation. The main goal of MI and AO is to reduce arthrogenic muscle inhibition (AMI), a condition in which the quadriceps "shuts down" after surgery due to pain, swelling, and joint receptor damage, hindering full contractions and slowing functional recovery.

During MI, the patient imagines performing movements, e.g., controlled knee extensions or squats, while AO involves observing correct movement patterns, e.g., via video. These methods activate the motor cortex and central motor pathways, supporting faster muscle activation and improved motor unit recruitment postoperatively. Studies have shown that adding MI to standard TKA rehabilitation may improve quadriceps strength (SMD ≈ 0.88) and reduce pain (SMD ≈ 0.63) [6,7]. This enables patients to regain knee function more quickly, with more effective neuromuscular activation post-surgery.

Alongside this, graded motor imagery (GMI) therapy would be clearly safe and effective for patients awaiting knee arthroplasty surgery. GMI is a staged neurorehabilitation approach consisting of three sequential components: (1) laterality recognition, in which patients cognitively identify left versus right limb images to activate motor planning networks without physical movement; (2) explicit MI, involving first-person mental simulation of functional movements without joint loading; and (3) mirror therapy, which provides visual feedback to reinforce non-threatening movement representations.

Recent evidence suggests that GMI training may produce clinically meaningful effects in orthopaedic rehabilitation, extending beyond pain modulation to functional motor recovery. In a randomized controlled study [8], the addition of structured MI training to conventional physiotherapy resulted in faster recovery of gait performance, reduced pain, and a lower incidence of falls compared with standard rehabilitation alone. Patients who underwent GMI training demonstrated significantly better functional mobility, as assessed by the TUG test, indicating superior integration of motor control during real-world walking tasks. Importantly, the authors emphasized that "[…] our MI improvement generalized to real walking, with better recovery of motor performance for actual gait, as measured by the TUG test," [8:5] highlighting a clear transfer from imagined to performed movement.

Beyond gait speed and mobility, the GMI group also showed a reduced number of falls and near-falls during follow-up, suggesting improved postural control and safer locomotion. These findings indicate that GMI does not merely influence subjective perception of movement, but actively enhances sensorimotor organization and movement execution. From a prehabilitation perspective, introducing GMI before TKA may therefore be particularly advantageous. Preoperative exposure to GMI could prime central motor representations, reduce maladaptive protective movement strategies, and establish more efficient gait and movement patterns prior to surgery. As a result, patients entering postoperative rehabilitation may demonstrate earlier functional engagement, reduced fear of movement, and faster restoration of walking ability, having already learnt and cognitively integrated the principles of GMI.

While direct evidence for preoperative application is still limited, this transfer of MI-induced improvements to real motor performance supports the hypothesis that prehabilitation-based GMI could contribute to accelerated and safer postoperative recovery following TKA, particularly in terms of gait quality, functional mobility and fall risk reduction. Importantly, GMI is especially suitable for patients awaiting knee arthroplasty because it does not require large-amplitude or loaded movements of the symptomatic joint, thereby minimizing the risk of pain provocation, avoidance behaviours, or reinforcement of maladaptive movement patterns, and allowing effective neural preparation without exacerbating the patient's condition.

In addition to the interventions discussed above, proprioceptive neuromuscular facilitation (PNF) may offer a targeted and safe approach to prehabilitation before TKA. Evidence from RCTs in knee osteoarthritis populations [9] shows that specific PNF techniques, such as rhythmic stabilization, hold-relax, and contract-relax patterns, significantly improve pain, joint ROM, balance, and functional mobility compared to conventional physiotherapy. For instance, rhythmic stabilization, involving isometric co-contractions against manual resistance in multiple directions, enhanced knee joint stability and proprioceptive acuity, leading to improved balance and a reduced risk of falls. Hold-relax and contract-relax stretching applied to the quadriceps and hamstrings increased flexibility and ROM, while simultaneously decreasing protective muscle guarding, which can limit functional movement. Patients demonstrated improvements in functional tests, such as the TUG, SLS, and gait parameters, indicating better neuromuscular control and movement efficiency during dynamic tasks. These effects are particularly relevant for prehabilitation, as they prime the neuromuscular system, reduce AMI, and optimize movement patterns without imposing high mechanical loads on the arthritic knee. Consequently, integrating PNF into pre-TKA programmes could facilitate safer and more efficient postoperative recovery by preparing patients with improved proprioception, balance, and functional mobility, while minimizing pain and risk of maladaptive movement patterns.

Discussion

The available evidence suggests that prehabilitation before TKA provides measurable benefits in reducing the hospital stay and preoperative pain. The effects on postoperative physical function and muscle strength remain inconclusive. Incorporation of NMES, BFRT, MI, AO, GMI, and PNF could potentially enhance programme effectiveness, particularly with respect to quadriceps strength and neuromuscular activation; importantly, these interventions may also represent a safe and low-pain preoperative strategy, as they allow neuromuscular priming with minimal mechanical load on the affected joint and a low risk of pain provocation or symptom exacerbation. Nevertheless, further clinical research is required to establish optimal protocols.

Conclusions

Prehabilitation may improve patient preparation for TKA by reducing preoperative pain and shortening the hospital stay. Incorporating modern techniques such as NMES, BFRT, GMI, PNF, and AO may further enhance programme effectiveness, especially in terms of muscle strength and function, but additional studies are needed to confirm efficacy and determine optimal training parameters.

References

1. Huber E.O., Roos E.M., Meichtry A. et al. Effect of preoperative neuromuscular training (NEMEX-TJR) on functional outcome after total knee replacement: an assessor-blinded randomized controlled trial. *BMC Musculoskelet Disord* 2015;16,101, https://doi.org/10.1186/s12891-015-0556-8.
2. De Klerk TC, Dounavi DM, Hamilton DF, Clement ND, Kaliarntas KT. Effects of home-based prehabilitation on pre- and postoperative outcomes following total hip and knee arthroplasty. *Bone Jt Open*.

2023;4(5):315–328, https://doi.org/10.1302/2633-1462.45.BJO-2023-0021.
3. Peng L, Wang K, Zeng Y, Wu Y, Si H, et al. Effect of Neuromuscular Electrical Stimulation After Total Knee Arthroplasty: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Front Med.* 2021;8:779019, https://doi.org/10.3389/fmed.2021.779019.
4. Tiss B, Layouni S, Ghali H, Ceylan Hİ, Nticha I, et al. Blood Flow Restriction Training in Knee Arthroplasty: A Systematic Review of Current Evidence on Postoperative Muscle Strength and Function. *Medicina*. 2025;61(10):1879, https://doi.org/10.3390/medicina61101879.
5. Franz A, Ji S, Bittersohl B, Zilkens C, Behringer M. Impact of a six-week prehabilitation with blood-flow restriction training on pre- and postoperative skeletal muscle mass and strength in patients receiving primary total knee arthroplasty. *Front Physiol.* 2022;13:881484, https://doi.org/10.3389/fphys.2022.881484.
6. Ferrer-Peña R, Cuenca-Martínez F, Romero-Palau M, Flores-Román LM, Arce-Vázquez P, et al. Effects of motor imagery on strength, range of motion, physical function, and pain intensity in patients with total knee arthroplasty: A systematic review and meta-analysis, *Brazilian Journal of Physical Therapy* 2021;25(6):698–708, https://doi.org/10.1016/j.bjpt.2021.11.001.
7. Hyung SW, Moon JW, Lee ES, Jeong SE, Min JY. Effects of motor imagery in recovery of nerve blockade in patients undergoing total knee replacement under spinal anesthesia: a randomized prospective controlled study. *J Orthop Surg Res.* 2025;20(1):583, https://doi.org/10.1186/s13018-025-05936-4.
8. Zapparoli L, Sacheli LM, Seghezzi S, Preti M, Stucovitz E, et al. Motor imagery training speeds up gait recovery and decreases the risk of falls in patients submitted to total knee arthroplasty. *Sci Rep*. 2020;10(1):8917, https://doi.org/10.1038/s41598-020-65820-5.
9. Kalunke A. Effectiveness of rhythmic stabilization (PNF) vs. conventional physiotherapy in knee osteoarthritis. *JIMP*. 2024;1(4):22–29, https://doi.org/10.61920/jimp.v1i04.37.

MEDICINE & PUBLIC HEALTH