



Effect of Prehabilitation in Older Adults Undergoing Total Joint Replacement: an Overview of Systematic Reviews

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Abstract

Purpose of Review To review and discuss the findings of systematic reviews that synthesized the evidence on the effect of preoperative exercises (prehabilitation) on postoperative functional recovery in older adults undergoing total knee or hip joint replacement.

Recent Findings Ten systematic reviews (8 meta-analyses) were included in this review. Findings from the systematic reviews indicated that prehabilitation decreases length of hospital stay but does not improve postoperative functional recovery in older adults undergoing joint replacement. Individual studies in the systematic reviews varied considerably in prehabilitation protocol, assessment timepoints, and outcome measures. Most importantly, systematic reviews did not assess the outcomes pre-post prehabilitation, as this timepoint was not addressed in most individual studies. Therefore, it is not known whether the prehabilitation programs improved outcomes preoperatively.

Summary There is a need to develop comprehensive prehabilitation protocols and systematically assess the preoperative and postoperative effectiveness of prehabilitation protocols on functional outcomes (i.e., self-reported and performance-based) in older adults undergoing total joint replacement.

Keywords Prehabilitation · Preoperative exercise · Physical function · Total knee replacement · Total hip replacement · Osteoarthritis

Introduction

Knee and hip osteoarthritis (OA) are prevalent joint disorders in older adults and contribute significantly to functional impairments, sedentary behavior, and low quality of life. Other than the burden to the individual, knee and hip OA also poses a

significant burden to the health system. These conditions are among the most expensive to treat when joint replacement surgery is required. According to the Centers for Disease Control and Prevention, OA was the second most costly health condition treated at US hospitals in 2013, accounting for US\$16.5 billion in costs of hospitalizations [1]. Total joint replacement (TJR) is the most successful approach to decrease pain and improve mobility and quality of life in those suffering from severe OA. Despite the high cost, TJR is one of the most common elective surgical procedures in the USA. Total knee replacement (TKR) and total hip replacement (THR) surgeries may soon lead to a large economic burden in global health care, as they are expected to increase by 673% and 174%, respectively, between 2005 and 2030 [2, 3]. However, the elective nature of the surgery (i.e., long time gap between diagnosis and surgery) presents an opportune window for healthcare providers to improve function in individuals awaiting TJR and enhance postoperative functional recovery.

Preoperative exercises (prehabilitation) have gained significant attention in the last decade. The concept behind prehabilitation exercises is to prepare the individual for

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surgery by improving functional outcomes before surgery. Individuals with OA who are awaiting TJR have severe functional impairments and muscle weaknesses due to pain and lack of physical activity. Some studies suggested that a well-designed prehabilitation exercise program can improve pain, range of motion, physical function, and quality of life in individuals awaiting TJR [4–7]. These preoperative improvements seem to lead to improved outcomes postoperatively compared with individuals who followed the standard of care (i.e., no exercises done preoperatively). On the contrary, other studies have shown that prehabilitation exercises are not effective in improving postoperative outcomes.

To date, several systematic reviews and meta-analyses investigating the evidence about the effect of prehabilitation on postoperative outcomes have been published. These systematic reviews investigated the effect of prehabilitation on various postoperative outcomes such as pain, function, quality of life, lower extremity strength, and length of hospital stay. Due to discrepancies in original study findings, heterogeneity of outcomes and timepoints assessed, and type of question explored, several systematic reviews have reported inconclusive or contradicting results. The purpose of the current review is to synthesize the most recent evidence (past 5 years) on effectiveness of prehabilitation on postoperative functional recovery in older adults with knee or hip OA awaiting TJA from systematic reviews and meta-analysis. This review will examine the strengths and limitations of the current evidence and discuss applicability to clinical practice and recommendations for future research.

Materials and Methods

We searched several relevant databases (PubMed, EMBASE, and Cochrane) from inception up to June 2020. To avoid significant overlap in individual studies included in the systematic reviews and meta-analysis and to present evidence from the most recent research as suggested by the journal, we included reviews from 2015 to present. Systematic reviews and meta-analysis were included if they synthesized studies including preoperative exercises (prehabilitation) in older adults awaiting TKR and/or THR and included functional outcomes such as muscle strength and physical function (e.g., self-reported or performance-based). To address our aim, we searched for relevant articles combining the following terms: (“arthroplasty, replacement, knee” [MESH] OR “arthroplasty, replacement, hip” [MESH]) AND (exercise OR “rehabilitation”) AND (“preoperative period” [MESH] OR “prehabilitation” OR “pre-habilitation” OR “pre-rehabilitation” OR prerehabilitation) AND (“systematic review” OR “meta-analysis”). Two reviewers (GJA and SSK) reviewed all titles and abstracts identified through the search strategy and retrieved the full text when a study seemed appropriate to be

included in this review. The reviewers also hand searched the reference lists of articles to identify potential studies not detected by the search strategy.

Data from eligible systematic reviews were examined and extracted independently by two reviewers (GJA and SSK). The data extracted included information on author(s), year, knee or hip TJR, number and characteristics of the studies included in the systematic review, timepoint and outcomes-assessed, whether a meta-analysis was conducted, and quality assessment of the systematic reviews. Quality assessment was performed independently by two reviewers (GJA and SSK) using the Assessing the Methodological Quality of Systematic Reviews (AMSTAR-2) tool [8]. AMSTAR-2 contains 16 items that appraise the methodology used in the systematic reviews. Each item is scored as yes, partial yes, and no/NA. There is no total score. The presence of flaws and weaknesses translate in the overall confidence in the results of the systematic review. The overall confidence is rated as “critically low,” “low,” “moderate,” or “high.”

Results

A total of 28 titles and abstracts were reviewed. Most of the studies found in the literature search assessed outcomes of pain, range of motion, physical function, quality of life, and strength. Studies that included surgeries other than TJR or did not include an exercise intervention preoperatively and outcomes related to functional capacity were excluded from this review: 4 studies included surgeries other than TJR; 6 studies did not have a prehabilitation intervention; 4 studies did not include outcomes related to functional capacity; and 4 studies were published before 2015. From our search strategy, we found 10 articles that met our inclusion criteria and were included in this narrative review: 5 in TKR only and 5 in THR and TKR combined. Eight of the studies included in this review performed a systematic review with meta-analyses (Table 1) [9–11, 12••, 13, 14••, 15•, 16•]. All ten studies performed a quality assessment of the original studies. Upon full-text review, two of the systematic reviews used the same protocol (search strategy, selection criteria) and the same individual studies but differed in their analysis [9, 10]. Cabilan et al. assessed the effect of prehabilitation volume (number of minutes) on pain, function, and quality of life, [9] while Cabilan et al. assessed the effect of prehabilitation on pain at 1 and 3 months postoperatively and physical function at 3 months postoperatively [10]. These systematic reviews were treated as separate papers for the purpose of our review (Table 2).

Based on AMSTAR-2, the methodological quality of the systematic reviews ranged from low to moderate. The major flaws identified included not having an established review protocol a priori, lack of justification for selecting specific study designs for inclusion, not considering risk of bias when

Table 1 Characteristics of included studies

Systematic review (SR) study	Number of studies included in SR and sample size	Characteristics of included studies in SR	Timepoints investigated	Outcomes assessed	Description of intervention and comparisons	Meta-analysis performed?
Vasta et al. 2020 [18•]	14 studies (740 subjects)	RCTs, cohort, case-control designs, knee and hip OA, patients > 65 years	Not specified	Function (self and perform), ROM, QoL, pain, LoS	Described intervention, but comparison groups not described	No
Sharma et al. 2019 [16•]	5 studies (707 subjects)	RCTs, knee OA	3 months post-TKA	Pain, stiffness, function (self), QoL, LoS	Described intervention and comparison groups	Yes
Ma et al. 2018 [15•]	9 studies (777 subjects)	RCTs, knee OA	Not specified	Pain, ROM, QoL, function (self and perform), LoS	Described intervention	Yes
Chen et al. 2018 [14••]	16 studies (966 subjects)	RCTs, knee OA, patients > 18 years, English language	Not specified	LoS, strength, pain, stiffness, function (self and perform), ROM	Partially described intervention (duration and type, not in detail)	Yes
Peer et al. 2017 [13]	3 studies (82 subjects)	RCTs, knee OA, land-based prehabilitation programs, full description of intervention dose, duration, frequency, English or German language	Pre-prehab; postop: 6 and 12 weeks	Pain, stiffness, function (self and perform), strength	Described intervention in full details along with mode, dosage, setting, frequency, duration	Yes
Moyer et al. 2017 [12••]	35 studies (2956 subjects)	RCTs, CPGs and SRs, knee and hip OA, published after 2000, English language	Pre-prehab; postop: < 6 weeks, 3 months, > 6 months	Pain, function (self), strength, anxiety, LoS	Described intervention adequately	Yes
Wang et al. 2016 [11]	22 studies (1492 subjects)	RCTs, knee or hip OA	Pre-prehab; postop: 1–12 months	Pain, function (self), QoL, LoS	Described intervention adequately	Yes
Cabilan et al. 2016 [9]	17 studies (1424 subjects)	RCTs, knee or hip OA, patients > 18 years	Pre-prehab; postop: 1, 3, 6, 12 months	Function (self and perform), HC util, QoL, pain	Described intervention, dosage and volume provided	Yes
Kwok et al. 2015 [17]	11 studies (741 subjects)	RCT or quasi-experimental design, knee OA	Not specified	Pain, stiffness, function, QoL, strength, pain, ROM, LoS	Partially described intervention (duration and type, not in detail)	No
Cabilan et al. 2015 [10]	17 studies (1424 subjects)	RCTs, knee or hip OA, patients > 18 years	Pre-prehab; postop: 1, 3, 6, 12 months	Function (self and perform), HC util, QoL, pain	Described intervention, Dosage and volume provided	Yes

RCT randomized clinical trials, QoL quality of life, LoS length of stay

Table 2 Effect of prehabilitation on postoperative outcomes compared with usual care or no prehabilitation

Study	Physical function	Quadriceps strength	Range of motion	Length of hospital stay	Pain	Quality of life
Vasta et al. 2020 [18•]	No difference	Not assessed	Not assessed	Significant reduction	No difference	No difference
Sharma et al. 2019 [16•]	No difference		Not assessed	Significant reduction	No difference	No difference
Ma et al. 2018 [15•]	No difference	No difference	Not assessed	Significant reduction	No difference	No difference
Chen et al. 2018 [14••]	Improvement seen for sit-to-stand tests but not in other measures of physical function	No difference	Improved	Significant reduction	No difference	Not assessed
Peer et al. 2017 [13]	No difference	No difference	Not assessed	Not assessed	No difference	No difference
Moyer et al. 2017 [12••]	Moderate and significant improvement overall (post-TKA and THA). Subgroup analysis showed moderate improvements 3 months and after effective prehabilitation programs in the THA subgroup	Moderate and significant improvement overall. Moderate and significant improvement 3 months post-TKA and after effective and ineffective programs in TKA subgroup	Not assessed	Significant reduction overall. Subgroup analysis showed significant reduction in patients post-TKA	Subgroup analysis showed small but significant improvements 3 months post-THA and after effective prehabilitation programs for THA. No improvements post-TKA	Not assessed
Wang et al. 2016 [11]	No difference	Not assessed	Not assessed	No difference	No difference	No difference
Cablan et al. 2016 [9]	No difference	Not assessed	Not assessed	Not assessed	No difference	No difference
Kwok et al. 2015 [17]	No difference	No difference	No difference	No difference	No difference	No difference
Cablan et al. 2015 [10]	No difference	Not assessed	Not assessed	Not assessed	No difference	No difference

interpreting the results of the review, and not assessing publication bias (Table 3).

Five systematic reviews specified timepoints of interest [9–11, 12••, 13], which varied from prior to start of prehabilitation up to 12 months postoperatively. None of the systematic reviews reported the effectiveness of prehabilitation preoperatively, but one of them reported improvement in postoperative outcomes based on the preoperative effectiveness of the prehabilitation program [12••]. Most studies described the prehabilitation programs in detail, although detailed information on exercise intensity or frequency was not always available. Prehabilitation programs varied by exercise modes (e.g., aerobic vs. anaerobic; land-based vs. water-based; proprioceptive training), delivery (home-based vs supervised), duration (range 4 to 12 weeks), and frequency (range once per week to daily). Comparison groups usually

consisted of standard preoperative care, no preoperative care or restrictions, postoperative care only, or education only. All the studies assessed pain and physical function (self-reported or performance-based). A few studies assessed length of hospital stay, [11, 12••, 14••, 15•, 16•, 17, 18•] quality of life, [9–11, 13, 15•, 16•, 17, 18•], quadriceps strength, [12••, 13, 14••, 17], and range of motion [14••, 17] (Table 2).

Effect of Prehabilitation on Postoperative Functional Recovery

Physical function was assessed in all ten systematic reviews. Only two systematic reviews reported that prehabilitation improved physical function compared with controls [12••, 14••], while the remaining eight did not show significant postoperative differences in physical function between the

Table 3 Methodological Quality of Systematic Reviews and Meta-Analysis, assessed by AMSTAR-2

Study author and year	AMSTAR-2 checklist items*																Overall quality (low/mod/high)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Vasta et al. 2020 [18•]	Y	N	N	P	Y	N	Y	Y	Y	N	NA	NA	Y	N	NA	N	Moderate
Sharma et al. 2019 [16•]	Y	P	N	P	Y	N	P	Y	P	Y	Y	N	Y	Y	N	Y	Moderate
Chen et al. 2018 [14••]	Y	N	N	P	N	Y	N	P	Y	N	Y	N	N	N	N	Y	Low
Ma et al. 2018 [15•]	Y	Y	N	P	Y	Y	N	P	Y	N	Y	Y	Y	Y	Y	Y	Moderate
Peer et al. 2017 [13]	Y	N	Y	P	N	N	Y	Y	Y	N	Y	N	N	Y	N	N	Low
Moyer et al. 2017 [12••]	Y	N	N	P	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Moderate
Wang et al. 2016 [11]	N	P	N	P	Y	Y	N	P	Y	N	Y	Y	N	Y	N	N	Low
Cabilan et al. 2016 [9]	Y	P	Y	Y	Y	N	Y	Y	Y	N	Y	Y	N	N	N	N	Moderate
Kwok et al. 2015 [17]	Y	P	N	P	N	N	N	P	Y	N	NA	NA	Y	Y	NA	Y	Moderate
Cabilan et al. 2015 [10]	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	Moderate

Y yes, N no, P partial yes, NA not applicable

Description of the numbered items:

1. Research question and inclusion criteria include components of PICO.
2. Systematic review methods were established a priori.
3. Selection of study design explained.
4. Comprehensive literature strategy used.
5. Study selection performed in duplicate.
6. Data extraction performed in duplicate.
7. List of excluded studies with explanation provided.
8. Included studies described in adequate detail.
9. Risk of bias (RoB) in individual studies assessed.
10. Funding source of included studies provided.
11. Meta-analysis conducted using appropriate methods.
12. Potential impact of RoB on the meta-analysis assessed.
13. Impact of RoB in individual studies on the review was discussed.
14. Heterogeneity among studies was assessed and discussed.
15. Publication bias assessed.
16. Conflict of interest reported.

*The AMSTAR-2 Checklist consists of 16 items and is rated based on the presence of weaknesses in critical domains. There is no overall score [8]

prehabilitation and control groups. Moyer et al. showed significant improvement in self-reported physical function 3 months (SMD = 0.31, 95% CI [0.04, 0.59]) and over 6 months after THR (SMD = 0.39, 95% CI [0.10, 0.69]) but not after TKR (SMD = 0.39, 95% CI [-0.01, 0.79] and SMD = 0.10, 95% CI [-0.15, 0.36], respectively) [12••]. Chen et al. showed that prehabilitation improved sit-to-stand scores after TKR (mean difference = 1.68, 95% CI [1.25–2.1]), but 6-min walk test or self-reported function scores did not as compared with control group [14••]. Quadriceps strength was assessed in four systematic reviews, and only one systematic review demonstrated that prehabilitation improved postoperative quadriceps strength. Moyer et al. indicated that prehabilitation improved quadriceps strength 3 months after TKR compared with control group (SMD = 0.59, 95% CI [0.17, 1.01]), but these improvements did not persist after 6 months (SMD = 0.23, 95% CI [0.07, 0.52]) [12••]. Range of motion was assessed in two systematic reviews. Chen et al. indicated that prehabilitation improved knee range of motion after TKR (mean difference = 3.62, 95% CI [0.05, 7.19]) compared with control group [14••], while Kwok et al. reported no significant differences between prehabilitation and control groups [17].

Effect of Prehabilitation on Other Postoperative Outcomes

Length of hospital stay was assessed in seven systematic reviews. Five of those reviews indicated that prehabilitation reduced the length of hospital stay postoperatively by 1 to 2 days compared with control groups [11, 12••, 14••, 15•, 16•, 17, 18•]. Pain was assessed in all systematic reviews. Only Moyer et al. demonstrated that prehabilitation resulted in small but significant reduction in pain at 3 months after THR (SMD = 0.34, 95% CI [0.07, 0.62]) but not after TKR (SMD = 0.12, 95% CI [-0.13, 0.37]) compared with control groups [12••]. The other studies reporting on pain did not show a significant difference between intervention and control groups. Lastly, none of the studies reported a significant difference between prehabilitation and control groups on quality of life measures.

Discussion

The present review summarizes the current knowledge about the effect of prehabilitation on functional recovery in older adults undergoing joint replacement. The systematic reviews identified in our search had a considerable overlap of randomized clinical trials included. Yet, results of their syntheses varied across some of similar outcomes investigated. Results from the majority of the reviews did not find a positive effect of prehabilitation on outcomes related to function (i.e., physical function, quadriceps strength, and range of motion). It is also relevant to mention that

prehabilitation does not appear to improve pain or quality of life in those undergoing TJR. However, prehabilitation has shown effectiveness to reduce the length of hospital stay. We postulate that the reduction in hospital stay could be attributed to the individuals learning more about the surgery, familiarizing themselves with different exercises during the prehabilitation program, and probably setting realistic postoperative expectations, which may have resulted in lesser days in the hospital. The reduction in length of hospital stay may be of significant interest to providers and healthcare systems as it can lead to lower healthcare costs and quicker transition to outpatient rehabilitation, which may accelerate postoperative recovery.

Evidence has shown that muscle volume, muscle strength, flexibility, and functional ability are critical preoperative predictors for a successful early recovery in individuals undergoing TJR [19–22]. For years, researchers have strived to build evidence on the effectiveness of prehabilitation to accelerate functional recovery after orthopedic surgeries such as TJR. However, studies have not consistently found prehabilitation to improve postoperative function (as evident in our review). There are multiple reasons to justify the insufficient evidence regarding positive effects of prehabilitation programs:

- (1) Systematic reviews have not assessed the effectiveness of prehabilitation programs preoperatively. This is key to learn whether the program was effective or not in improving strength and physical function preoperatively. If prehabilitation did not improve strength and physical function outcomes preoperatively, it may not improve postoperative recovery.
- (2) Systematic reviews have not assessed the influence of individual patient characteristics on outcomes post-prehabilitation or postoperatively. Variations in severity of osteoarthritis, comorbidities, age, and preoperative functional level may have contributed to the varied results.
- (3) Prehabilitation programs across studies reported in the systematic reviews were too heterogenous (in terms of mode, intensity, frequency, and duration) to be combined.
- (4) Most studies reported in the systematic reviews did not appear to use recommended exercise dose/intensity to generate muscle gains. The American College of Sports Medicine recommends that resistance exercises should be done at 70–80% of individual's maximum effort (i.e., 1 repetition maximum) to improve muscle strength and volume. Such exercise intensity may not be tolerated by individuals with OA, which may reduce compliance with the prehabilitation program.
- (5) None of the systematic reviews assessed compliance with the prehabilitation program nor was there sufficient data to stratify effectiveness of prehabilitation programs based on exercise dosage.

Several studies tested different types of prehabilitation programs with very few being successful at improving postoperative functional outcomes. It appears that the biggest barrier encountered in those studies is tolerance to resistance exercises. Many individuals with osteoarthritis of the lower extremities are not able to tolerate the recommended dosage of resistance exercise (i.e., 70–80% of maximum effort). The recommended exercise load might exacerbate pain and lead to reduced compliance with exercise program. Based on the information from the studies assessed by the systematic reviews included in this review, it is not clear whether prehabilitation programs used the recommended exercise dosage. While studies have tested a variety of exercises to reduce the mechanical/joint load, they may not have achieved the desired exercise intensity and, therefore, were unsuccessful in improving functional recovery postoperatively. When designing a prehabilitation program for older adults awaiting TJR, it is imperative to consider alternate exercise interventions that are tolerable and effective to improve muscle and physical function.

Alternative approaches to traditional resistance training that help minimize mechanical load while still providing the physiologic gains include neuromuscular electrical stimulation (NMES) and blood-flow restriction (BFR). NMES is one of the most common alternative resistance training modalities in the rehabilitation field. NMES has shown to improve quadriceps muscle volume, strength, and quality (i.e., amount of fat infiltration in the muscle) by applying a low NMES dosage of 10–20% of individual's maximal quadriceps voluntary contraction [23]. It is hypothesized that the improvements in muscle strength resulted from NMES interventions are due to the metabolic stimuli that lead to neural adaptations [24]. Low-resistance exercises with blood-flow restriction (BFR) are a more recent approach to resistance exercise and have garnered significant attention from rehabilitation professionals. The approach is attractive because resistance exercises using BFR require a low load (< 50% of the individual's maximum muscle voluntary contraction) to produce the same effect as volitional exercises applied at high loads (> 70% of the individual's maximum muscle voluntary contraction) [25]. Studies have also shown that the low mechanical load with BFR also results in significant morphological and neuromuscular adaptations in the skeletal muscles (e.g., increase in growth hormone and insulin-like growth factor [25–28]). Therefore, switching from a mechanical to a metabolic load during exercises may be beneficial in individuals with joint degeneration [29]. Implementing interventions such as NMES and low-resistance BFR training during prehabilitation may be more tolerable to individuals awaiting TJR and may lead to an accelerated postoperative recovery.

This review has its limitations. Our conclusions were drawn based on systematic reviews of low to moderate quality. Even though the systematic reviews identified overlapped considerably in terms of original studies included, results from

the reviews varied due to the different ways the outcomes were analyzed. Further, none of the systematic reviews assessed the effect of prehabilitation prior to surgery. To that end, future studies with rigorous methodology are warranted to test the effect of prehabilitation with adequate dosage and alternate exercise approaches such as NMES and BFR. One important consideration is assessing the effect of prehabilitation on outcomes prior to surgery, to determine whether the prehabilitation program was successful. Studies should standardize the reporting of outcomes, measure effectiveness of the prehabilitation programs preoperatively, and assess compliance. To improve methodological quality, future studies should follow guidelines such as the CONSORT Statement (for randomized clinical trials) and the AMSTAR (for systematic reviews and meta-analyses).

Conclusions

Prehabilitation is effective in reducing the length of hospital stay in older adults undergoing TJR. However, there is little evidence supporting the effectiveness of prehabilitation in improving outcomes related to function and quality of life pre- and postoperatively. Future studies should develop and test innovative interventions that are effective in improving muscle strength and function and that can be well tolerated by older adults awaiting TJR.

Compliance with Ethical Standards

Conflict of Interest Gustavo J. Almeida and Samannaaz S. Khoja have nothing to disclose. Boris A. Zelle has consulted for KCI Inc. USA and DePuySynthes® and received compensation. Dr. Zelle has received speaker fees from AO North America and research grants from DePuySynthes, KCI, Department of Defense, and the Orthopedic Trauma Association. Dr. Zelle has received educational grants from Smith and Nephew Inc. and Arthrex®. None of these activities are related to the content of this article.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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