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Effect of Physical Therapy Interventions in the Acute Care Setting on Function, Activity, and Participation After Total Knee Arthroplasty: A Systematic Review

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ABSTRACT

Background: Despite seemingly routine use of physical therapy and its potential importance in reducing complications after total joint arthroplasty in the acute hospital setting, no agreed-upon approach to rehabilitation exists in this setting. In fact, rehabilitation practices and outcomes assessed are quite variable.

Purpose: To determine the effects of physical therapy interventions in the acute care phase of total knee arthroplasty.

Data Sources: Ovid Medline, Cochrane Database of Systematic Reviews, CINAHL.

Review Selection Criteria: Peer-reviewed research from January 1996 to October 2016 of adults with primary total knee arthroplasty receiving any physical therapy intervention related to body systems/function impairments or activity/participation limitations measured within 7 days of surgery. All studies included a comparison group.

Data Extraction: Two reviewers extracted data and determined study quality.

Data Synthesis: Qualitative summary considering studies' risk of bias and number favoring interventions for outcomes.

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Results: Thirty-nine studies were included. Interventions included extra therapy, accelerated therapy, cryotherapy, Chinese medicine, lymphatic drainage, mechanical and manual passive motion, active-assistive motion, biofeedback, and electrical stimulation. Most studies included undefined "standard care." Outcomes varied, with pain and knee motion commonly reported.

Conclusions: Evidence supports cryotherapy for reducing pain and accelerated therapy for improving range of motion and walking, but quality is low. High-quality studies in these areas are needed.

Growth in the population of active older adults has resulted in an increasing prevalence of degenerative and end-stage arthritis and a growing demand for total joint arthroplasty (TJA) as an effective treatment for the pain and activity.[1-3] According to the Canadian Institute for Health Information and the United States Agency for Healthcare Research and Quality, from 2010 to 2011, a total of 762 000 total knee arthroplasty (TKA) procedures were performed in Canada and the United States. In 2014, hip and knee TJAs were the most common inpatient surgery for Medicare recipients, costing more than $7 billion.[4] The American Association of Orthopaedic Surgeons reported that more than 7 million people were living with TJA in 2010, including 4.7 million Americans with TKA.[5]

The Affordable Care Act, passed into law in the United States in 2010, included provisions that move the health care system away from a fee-for-service model toward models that bundle payments for an overall episode of care. In April 2016, the Centers for Medicare & Medicaid Services Innovation Center implemented the Comprehensive Center for Joint Replacement model initially in 67 US metropolitan areas to test a bundled payment model for TJA and encourage improved coordination and quality of care from surgery through all rehabilitation.[6] In this model, optimization of postsurgical outcomes relies on providers' appreciation of the type and severity of patients' bodily impairments, activity limitations, and participation restrictions, as well as the interventions that best address these at all stages of recovery.

Given the Comprehensive Center for Joint Replacement and the role played by physical therapists in the overall care of patients undergoing TJA, an understanding of the best approach to acute care rehabilitation of people with TJA is needed. In a 2012 study of 93 community hospitals in North Carolina, the mean percentage of patients with both hip and knee TJA receiving physical therapy was 98%.[7] Despite seemingly routine use of physical therapy and its potential importance in reducing complications[8] after TJA in the acute hospital setting, no approach to rehabilitation in this setting appears to be standard. Rehabilitation practices and outcomes, in terms of functional measures as well as length of stay, are quite variable.[7,9-12] Therapists now have even less time to evaluate, educate, and train these patients for their initial recovery phase, with patients now leaving the acute care setting as soon as same day of surgery or postoperative day (POD) 1. This variability of care may be related to a lack of evidence, low quality of evidence, or inconsistency in the evidence related to the effect of rehabilitation interventions.

Consistent with the aims of the Affordable Care Act and, specifically, the Comprehensive Center for Joint Replacement—providing people with the best care and securing the best outcomes after TJA—identifying best practices becomes imperative. Therefore, a systematic review of the literature published from January 1996 to October 2016 was performed to address the PICOT (Population, Issue, Comparison, Outcome, Timing) question: what is the effect of physical therapy interventions on impairments, activities, and participation following primary TKA in the early postoperative phase (7 days)? In addition, this review sought to identify gaps in knowledge to lay the groundwork for the development of new evidence needed to enhance clinical decision making.

RATIONALE FOR EARLY PHYSICAL THERAPY INTERVENTIONS POST-TKA

Total knee arthroplasty results in significant loss of quadriceps strength, decreased knee range of motion (ROM), and diminished functional abilities compared with preoperative measures.[13] Husted et al[14] noted that pain, dizziness, general weakness, and limitations in personal care and walking were primary reasons that patients with TJA were not discharged earlier. Chan et al[15] noted a negative correlation between pain and time each day spent walking in the post–acute care phase of TKA, suggesting that activity may be useful in managing pain. Lowe et al[16] found support for the use of functional exercises for improving function, range of joint motion, and quality of life 3 to

4 months postoperatively. The results from these studies suggest that pain, limitations in strength, ROM, and activity might be addressed by physical therapy interventions received in the acute care setting.

METHODS

Data Sources and Searches

A medical librarian derived search terms and strategies in consultation with one of the reviewers. Databases searched included Ovid Medline, Cochrane Database of Systematic Reviews, and CINAHL. The search strategy for Ovid Medline is outlined in Table 1. The other searches used similar terms but were slightly adapted by the librarian to meet the particular search engine specifications. Following selection of studies to include, we reviewed the reference lists of each to check for additional references that should be considered. No attempt was made to contact authors for data, nor did we search for unpublished studies.

Inclusion Criteria

Types of Studies, Language, and Dates

Studies published in peer-reviewed literature in English from 1996 through October 2016 were included.

Participants

Studies of adult participants with primary total knee replacement regardless of cause were included. Those with participants undergoing revision TKA or unicondylar or "partial" replacements were included if the data for these participants could be separated from those with primary TKA. In addition, studies including participants with conditions other than TKA were included if the data related to TKA were reported separately.

Interventions

Only studies with interventions that could be considered to be within physical therapists' scope of practice were included. However, the interventions may not have been administered by physical therapists in the study.

Outcomes and Timing

Studies with outcomes related to impairments of body systems/function or limitations in activity and participation, measured within 7 days of surgery or discharge from acute care hospital, were included. Those reporting outcomes later than 7 days were included only if the earlier data ($\leq$7 days) were separately reported. In addition, studies reporting data as being collected "at discharge" from the acute care hospital were included, regardless of length of stay, because the interventions provided and outcomes measured were within the acute care setting. Studies were included regardless of the method or measurement tool used to determine the outcomes.

Exclusion Criteria

Studies without comparison groups, case reports, and nonsystematic reviews of the literature were excluded because of their low level of evidence. Studies with participants undergoing revision TKA or unicondylar or "partial" replacements were excluded unless the data for these participants could be separated from those with primary TKA.

Data Extraction and Quality Assessment

Two reviewers independently read each unique title and abstract identified in the searches to determine whether they met the inclusion and exclusion criteria based on the study question. Any differences were discussed and resolved. If the 2 reviewers were unable to resolve a disagreement, a third reviewer was consulted to develop consensus. In some cases, where the abstract was unclear, the final decisions about inclusion or exclusion required reading the full text of an article. Questionable articles were reread by 2 of the reviewers and further decisions were made about their inclusion and exclusion. Any disagreements were resolved by discussion. Reasons for exclusion were documented on the basis of the PICOT question.

Two reviewers independently extracted and summarized data from each selected study. Discrepancies were noted and corrected by referring back to the study text and tables (see Supplemental Digital Content Table 2, available at: http://links.lww.com/JACPT/A4, and Supplemental Digital Content Table 3, available at: http://links.lww.com/JACPT/A5).

Two reviewers assessed the quality of each trial and determined the risk of bias based on that assessment. When the reviewers disagreed, consensus was reached through review of the text and discussion. Risk of bias was determined on the basis of 4 categories of criteria. (1) Selection bias: adequate method of randomization, allocation concealment; (2) performance bias: blinding of participants and assessors; (3) attrition bias: accounting for all participants and analysis of data within assigned groups at follow-up; and (4) reporting bias: full reporting of data for all analyses suggested in the "Methods" section. As most studies were not randomized controlled trials with published protocols, we could not determine whether the "Methods" section selectively excluded some of the measured outcomes; however, we did determine whether studies provided data for each of the outcomes indicated in

TABLE 1. Search Strategy for Ovid Medline

	Search Term
1	Arthroplasty, replacement, knee/
2	"Outcome and Process Assessment (Health Care)"/ or Patient Outcome Assessment/ or "Outcome Assessment (Health Care)"/ or Treatment Outcome/
3	outcome*.mp. [mp = title, abstract, original title, name of substance word, subject heading word, key word heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
4	2 or 3
5	rehabilitation/ or "activities of daily living"/ or early ambulation/or exercise therapy/ or motion therapy, continuous passive/ or muscle stretching exercises/ or plyometric exercise/ or resistance training/
6	physical therapy modalities/ or electric stimulation therapy/ or exercise movement techniques/ or exercise therapy/ or motion therapy, continuous passive/ or muscle stretching exercises/ or plyometric exercise/ or resistance training/ or hydrotherapy/ or musculoskeletal manipulations/ or kinesiology, applied/ or manipulation, orthopedic/ or manipulation, osteopathic/ or therapy, soft tissue/ or acupressure/ or massage/ manipulation, orthopedic/ or manipulation, osteopathic/ or therapy, soft tissue/ or acupressure/ or massage/
7	cryotherapy/ or hypothermia, induced/
8	pain/ or acute pain/ or breakthrough pain/ or musculoskeletal pain/
9	walking/ or dependent ambulation/
10	hydrotherapy/ or therapeutic irrigation/
11	5 or 6 or 7 or 9 or 10
12	pain/ or acute pain/ or breakthrough pain/ or musculoskeletal pain/
13	pain.mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
14	"Recovery of Function"/
15	"Quality of Life"/
16	walking/ or dependent ambulation/
17	walking speed.mp.
18	walking distance.mp.
19	Gait/
20	"range of motion, articular"/ or arthrometry, articular/
21	Locomotion/
22	physical endurance/ or exercise tolerance/
23	Postural Balance/
24	"Length of Stay"/
25	12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24
26	1 and 4 and 11 and 25
27	limit 26 to English language
28	Patient Discharge/
29	25 or 28
30	1 and 4 and 11 and 29
31	Limit 30 to English

the "Methods" section. The level of bias (high, moderate, low) was determined by whether the study met a 50% or more of the criteria in each of the 4 categories. Risk of bias was deemed low if 50% or more criteria were met in each category; moderate if 50% or more criteria were met in all but 1 category; and high if 50% or more criteria were not met in more than 1 category. Systematic reviews were assessed for quality using criteria from the Assessment of Multiple Systematic Reviews (AMSTAR) tool.[17]

Data Synthesis and Analysis

Given the variety of study methods, poorly reported data, and heterogeneous interventions and outcomes, we undertook a qualitative, summary analysis of the data, rather than quantitative. In determining our recommendations for practice, we simultaneously weighed the quality of studies, the number of participants represented by studies, and the number of studies favoring (or not) particular interventions for various outcomes. We derived recommendations through consensus.

RESULTS

Our search of electronic databases yielded 686 unique titles. Additional searching of reference lists garnered an additional 30 titles. Of these, 572 were excluded on the basis of the title and abstract reviews. We read 144 full-text articles. Subsequently, based on the full text, 104 studies were excluded as they failed to meet inclusion criteria. A total of 40 studies, including 2 systematic reviews, were included in this review (see Figure 1).

Risk of Bias

The studies had varying risks of bias (see Supplemental Digital Content Table 2, available at: http://links.lww.com/JACPT/A4, and Figures 2 and 3). Adequate methods of randomization were not applied in 9 studies[18-26] and randomization was unclear in 2 studies.[27,28] Concealed allocation was not accomplished in 16 of the studies[18-26,28-34] and in 2 it was not clear.[27,35] Most studies did not blind the participants due to the nature of the interventions; however, 8 studies provided sham interventions.[36-43] Methods used in 14 studies suggested that the assessors were not blinded,[19,20,22-24,26,28-30,33,34,40,42,44] and blinding of assessors was unclear in 9 other studies.[18,21,25,31,35,43,45-47] In 8 studies, the loss of participants suggested attrition bias,[23,25,26,30,32,42,43,48] and in 3 other studies, the degree of loss to follow-up was not clear.[20,21,46] Of those studies with clear or uncertain attrition bias, 10 did not appear to include intention to treat analysis.[20,21,25,26,30,32,42,43,46,48] Although we did not check for preregistration of trials, 7 studies demonstrated reporting bias in failing to provide data for all the outcomes suggested in the "Methods" section.[21,22,31,40,45,48,49] The risk of bias was low in the 2 systematic reviews.[50,51]

Effect of Interventions

Additional Sessions of Rehabilitation

Three studies with a total of 192 participants examined the effect of "additional sessions" of rehabilitation, that is, beyond the routine number of sessions provided at that facility.[19,42,52] One study with high risk of bias compared groups with 7 days and 6 days of therapy.[19] The authors failed to demonstrate an effect of the additional day of therapy on ability to meet goals at discharge, discharge placement, or length of hospital stay. The study did not report adverse events. Two studies, 1 with low[52] and 1 with moderate[42] risk of bias examined the effect of 2 sessions per day of walking or other physical therapy intervention compared with 1 daily session. No differences were found for knee ROM, function, pain, or patient satisfaction.

"Early" or "Enhanced" Rehabilitation

Five studies examined the effect of early or enhanced rehabilitation.[23-25,40,53] This intervention generally involved multidisciplinary protocols for optimizing pain management and aggressive and accelerated postoperative mobility protocols, for example, having patients walking within hours of the surgery. The studies included only 2 trials. One trial with low risk of bias and 273 participants reported favorable results for therapy initiated within 24 hours postoperatively compared with therapy started within 48 to 72 hours.[53] Knee ROM and knee strength were greater in the intervention group, and a greater proportion of participants in the early intervention group demonstrated normal gait and normal balance. Measurements were apparently completed at discharge from hospital, although the timing was not clearly stated. One trial with moderate risk of bias and 147 participants receiving the enhanced protocol reported differences in American Knee Society scores and Western Ontario and McMaster University Arthritis Index scores at POD 5 and POD day 7.[40] One study with high risk of bias included a total of 143 participants.[24] It reported that participants receiving the enhanced intervention demonstrated greater walking distance, more time out of bed, and less knee swelling at POD 5 but not POD 3, as well as more stairs climbed at POD 3 and POD 5 than the comparison group. None of the other outcomes, including pain, ROM, and length of stay were different between groups. The study also reported 2 severe

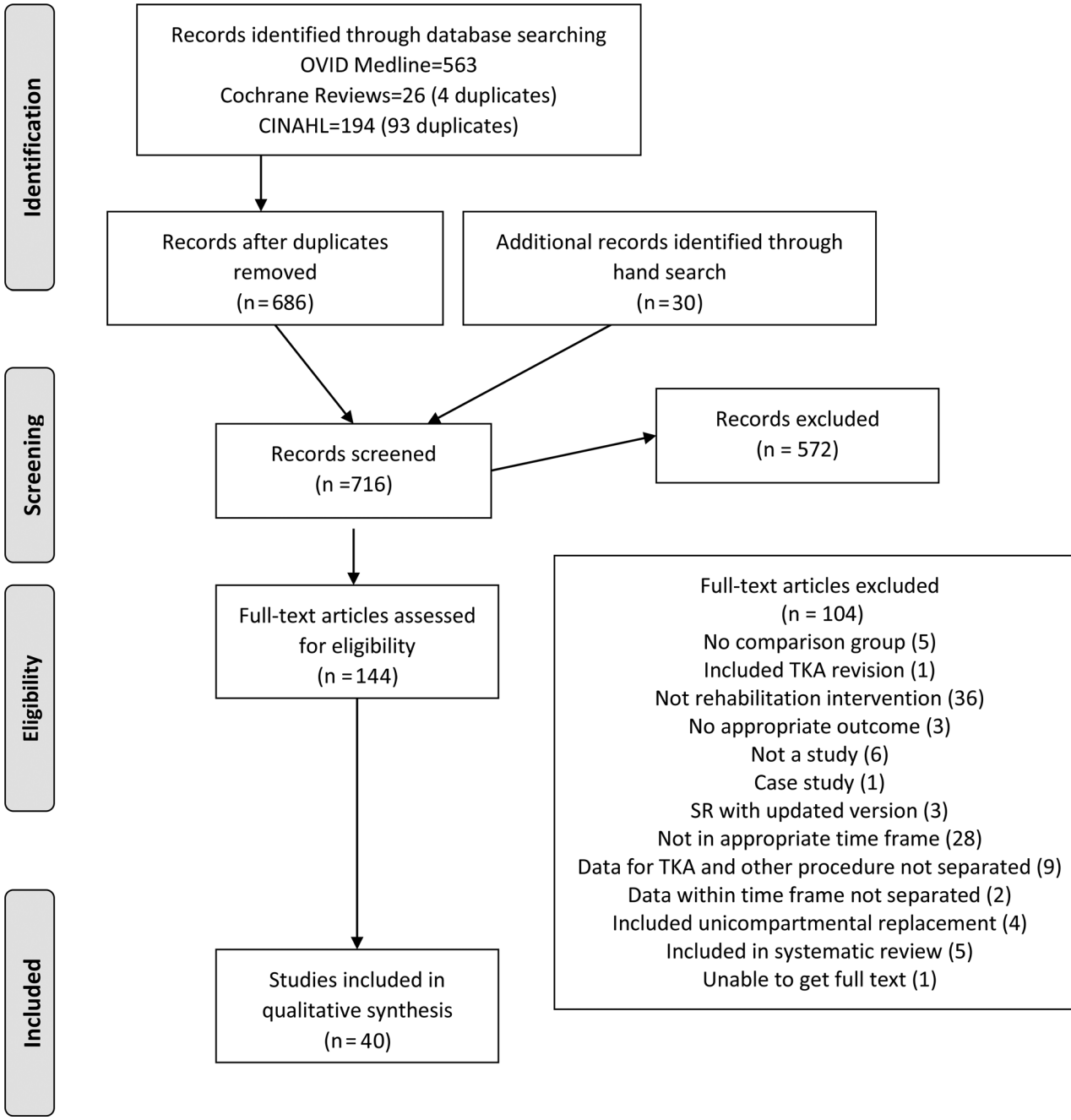

FIGURE 1. PRISMA Diagram. SR indicates systematic review; TKA, total knee arthroplasty.

(wound healing and hospital readmission) and 7 minor adverse events in the intervention group.

One observational study with a historic comparison group and data from 2344 patients reported that length of stay in hospital in the group receiving enhanced rehabilitation was 2 days shorter.[25] No statistical comparisons were provided.[25] One retrospective study in which patients were divided into groups that received therapy of POD 1 versus POD 2 included 1504 patients.[23] Differences were observed in ability to achieve 90° of knee flexion, improved odds of using less support for walking, and decreased length of stay and hospital costs in the group receiving the enhanced intervention.

Cryotherapy

We included 2 systematic reviews investigating the effects of cryotherapy. Adie et al[50] included 12 studies with 809 participants. Ni et al[51] included 12 studies with a total of 660 TKAs. Two studies on cryotherapy that were captured in our search but were not included in the systematic reviews are included here.[26,45] Both systematic reviews favored cryotherapy over any type

	Selection Bias		Performance Bias		Attrition Bias		Reporting Bias
	Random Assignment	Concealed Allocation	Participant Blinding	Assessor Blinding	Loss to Follow-up	Intention to Treat Analysis	Selective Reporting
Alaca, et al[29]	+	−	−	−	+	−	+
Alkire et al[28]	?	−	−	−	+	−	+
Beaupre et al[55]	+	+	−	+	+	+	+
Bennett et al[27]	?	?	−	+	+	−	+
Boese et al[30]	+	−	−	−	−	−	+
Borckardt et al[36]	+	+	+	+	+	−	+
Bruun-Olsen et al[56]	+	+	−	+	+	−	+
Chang et al[39]	+	+	+	+	+	+	+
Demoulin et al[45]	+	+	−	?	+	+	−
den Hertog et al[40]	+	+	+	−	+	+	−
Denis et al[57]	+	+	−	+	+	+	+
Ebert et al[54]	+	+	−	+	+	−	+
He et al[37]	+	+	+	+	+	+	+
Kim et al[18]	−	−	−	?	+	+	+
Labraca et al[53]	+	+	−	+	+	−	+
Lang[19]	−	−	−	−	+	+	+
Lau & Chiu[31]	+	−	−	?	+	−	−
Leach et al[32]	+	−	−	+	−	−	+
Lenssen et al[52]	+	+	−	+	+	+	+

FIGURE 2. Risk of Bias in Single Studies.

Maniar et al[46]	⊕	⊕	⊖	?	?	?	⊕
Mau-Moeller et al[44]	⊕	⊕	⊖	⊖	⊕	⊕	⊕
Munk et al[47]	⊕	⊕	⊖	?	⊕	⊖	⊕
Nigam et al[20]	⊖	⊖	⊖	⊖	?	⊖	⊕
Pereira and Jolles[33]	⊕	⊖	⊖	⊖	⊕	⊖	⊕
Pichonnaz, et al[48]	⊕	⊕	⊖	⊕	⊖	⊖	⊖
Pongkunakorn and Sawatphap[22]	⊖	⊖	⊖	⊖	⊕	⊕	⊖
Pope et al[21]	⊖	⊖	⊖	?	?	⊖	⊖
Pua, et al[23]	⊖	⊖	⊖	⊖	⊖	⊕	⊕
Rakel, et al[41]	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Renkawitz, et al[24]	⊖	⊖	⊖	⊖	⊕	⊕	⊕
Starks et al[25]	⊖	⊖	⊖	?	⊖	?	⊕
Thienpont[26]	⊖	⊖	⊖	⊖	⊖	⊖	⊕
Tsang et al[38]	⊕	⊕	⊕	⊕	⊕	⊖	⊕
Wang et al[34]	⊕	⊖	⊖	⊖	⊕	⊕	⊕
Wanich et al[43]	⊕	⊕	⊕	?	⊕	⊖	⊖
Yang et al[35]	⊕	?	⊖	?	⊕	⊕	⊕
Yashar et al[49]	⊕	⊕	⊖	⊕	⊕	⊕	⊖
Zietek et al[42]	⊕	⊕	⊕	⊖	⊖	⊖	⊕

Key: ⊕ Criterion met ⊖ Criterion not met ? Unable to determine if criterion met

FIGURE 2. (*Continued*).

	Duplicate Process in article selection and data abstraction	Comprehensive Search	Scientific Quality of Included Studies assessed	Scientific Quality of Included Studies considered in conclusions	Methods used to combine data	Assessment of Publication Bias
Adie, et al[50]	⊕	⊕	⊕	⊕	⊕	⊕
Ni, et al[51]	⊕	⊖	⊕	⊖	⊕	⊕

Key: ⊕ Criterion met ⊖ Criterion not met ? Unable to determine if criterion met

FIGURE 3. Risk of Bias in Systematic Reviews.

of comparison for improvements in pain at POD 2. The Adie et al[50] systematic review also favored cryotherapy over any type of comparison for improving knee ROM at discharge. The results for pain at POD 1 and POD 3, knee ROM at POD 1, swelling, and length of stay were not significant in either systematic review. Adie et al[50] determined that the level of evidence was "very low" for most outcomes. The most common adverse events were discomfort due to the cold temperature, necessitating withdrawal of its application. The 2 studies that we identified that were not in either systematic review included a total of 182 participants. Demoulin et al[45] with moderate risk of bias examined the effect of gaseous CO_2 over cold pack and Cryocuff (Aircast, Vista, California) for pain, swelling, and knee ROM for 88 participants. Thienpont[26] had a high risk of bias and compared continuous computer-assisted cryotherapy with intermittent cold pack. The studies reported no effects on pain, knee ROM, walking, knee swelling, or length of stay. No adverse events were reported in either study.

Acupressure, Acupuncture, and Traditional Chinese Medicine

Four studies including 223 patients examined the effect of some form of traditional Chinese intervention.[35,37-39] Two studies with low risk of bias examined the effect of acupressure compared with sham acupressure.[37,39] He et al[37] demonstrated a positive effect on pain at POD 3 through POD 7. Differences between groups, however, were less than 1 point on a scale of 0 to 10. The other study found no effect on pain but positive effects on passive knee ROM.[39] Adverse events, reported in one study, included nausea and vomiting, dizziness, and urinary retention.[37]

Tsang et al[38] examined the effect of acupuncture over sham acupuncture and no differences between groups for pain, knee ROM, and ambulation status at POD 4. The study did not report adverse events but was found to show low risk of bias.

Yang et al[35] reported the use of traditional Chinese medicine. This study showed moderate risk of bias. One intervention group combined traditional Chinese medicine with nonsteroidal anti-inflammatory drugs, physical therapy, and continuous passive motion (CPM), and 1 intervention group combined it with nonsteroidal anti-inflammatory drugs and CPM. The comparison group received nonsteroidal anti-inflammatory drugs, physical therapy, and CPM. The findings favored both intervention groups over the comparison group for pain and active knee extension. Two infections occurred in one of the intervention groups.

Compression and Manual Lymph Drainage

Three studies and a total of 195 participants reported the effects of some type of compression or massage to promote lymphatic drainage and reduce swelling.[47,48,54] One study with moderate risk of bias reported no effect of compression stocking compared with no compression stocking postoperatively on swelling pain and knee ROM.[47] Two studies examined the effects of manual lymphatic drainage (MLD).[48,54] In one study with low risk of bias, MLD was combined with CPM and cryotherapy and compared with exercise only.[54] The findings favored the intervention group for improvements in knee flexion for 1 of 2 measurements on POD 4 only. Results were not significant for ROM during other PODs or for pain and swelling. The study reported one complication of deep vein thrombosis. The other study of MLD had a high risk of bias.[48] It compared MLD with standard rehabilitation to relaxation with standard rehabilitation and reported no effect of treatment on measures of pain, ROM, gait, or swelling. Adverse events were not reported.

Knee ROM-CPM

Twelve studies with 1067 participants reported on the use of CPM in postoperative management.[18,21,27,28,30-32,46,49,55-57] One study with high risk of

bias reported positive effects of active CPM over a static hold in knee flexion on length of stay.[30] The control group with static hold in flexion and no CPM demonstrated less swelling than the intervention group below the joint line only. One study with moderate risk of bias reported positive results for a group receiving more aggressive (greater knee ROM) CPM over a group receiving less aggressive CPM, and an exercise-only group on active and passive knee flexion at POD 5 and pain over the course of 5 days.[27] One study with high risk of bias favored CPM done 23 hours per day for 6 days over immobilization for a significant improvement in total ROM at POD 7.[31]

Eight studies ranging from low to high risk of bias reported no effect of CPM on knee ROM.[21,28,30,32,46,55-57] Four studies ranging from low to high risk of bias reported no effect on CPM on length of stay.[27,28,49,57] Three studies with moderate risk of bias[32,46,56] and 1 with high risk of bias[30] showed no effect of CPM on pain. Two studies with moderate risk of bias[46,56] and 1 with high risk of bias[28] reported no effect of CPM on knee swelling. Two studies, 1 with low risk of bias[57] and 1 with moderate risk of bias[46] reported no effect of CPM in function as measured by the Timed Up and Go test or Western Ontario and McMaster Universities Osteoarthritis Index.

Seven studies reported adverse events.[21,27,28,30,31,49,57] They included wound infections or increased drainage, pulmonary embolism, deep and superficial vein thromboses, hematoma, cardiovascular issues, urinary retention and infection, a need for manipulation or revision, and temporary peroneal palsy.

Knee ROM-Manual Passive Exercise

Various types of manual passive knee ROM were reported in 3 studies.[18,22,33] One study with moderate risk of bias reported no effect of having 20 minutes of passive ROM by a physical therapist added to a regimen of active ROM, quadriceps strengthening, gait training, and CPM on pain or knee flexion ROM.[18] Another study with moderate risk of bias reported no effects of A+ joint mobilization for the knee on ROM, pain, or length of stay.[33] A third study with high risk of bias examined the effect of "drop and dangle" technique for achieving knee flexion compared with CPM.[22] Increased knee flexion was demonstrated at POD 1, POD 2, and discharge.

Knee ROM-Active-Assistive Exercise

Three studies with 177 participants examined the effect of active assistive exercise equipment.[29,44,55] One study with low risk of bias examined the effect of adding a slider board to a standard exercise regimen to assist participants with independent, low-friction, active exercises for knee extension and flexion.[55] This intervention group was compared with groups receiving CPM with a standard exercise regimen and the standard exercise regimen only. No significant results were reported for knee flexion or extension ROM at discharge. Adverse events included hematoma, erythema, and increased swelling. Another study with moderate risk of bias examined the effect of adding independent sling active-assisted exercise for knee flexion and extension to a standard physical therapy regimen.[44] The study compared the intervention to CPM with a standard physical therapy regimen. The study reported greater passive knee flexion and better score for Hospital for Special Surgery Knee Score (HHS)-ROM. Nonsignificant results were reported for activity level, balance and postural control, length of stay, pain, and function. Adverse events were not reported. A third study examined the effects of a specific proprioceptive neuromuscular facilitation technique in combination with a standard post-TKA program compared with the standard program alone.[29] No differences were found for knee ROM or walking. Several adverse events were reported including urinary retention, lumbar radiculopathy, abscesses, and urinary tract infection.

Biofeedback

One study with moderate risk of bias investigated the effects of biofeedback with CPM compared with CPM without biofeedback.[34] Pain was less in the intervention group over 5 PODs.

Neurostimulation

Four studies with 443 participants examined the effect of external electrical stimulation modes.[20,36,41,43] One study with high risk of bias favored neurostimulation using interactive, varying stimulation parameters in addition to "standard rehabilitation" over "standard rehabilitation" for pain and active knee flexion.[20] No effect of intervention on knee swelling was observed. Adverse events were not reported. Another study with moderate risk of bias applied neuromodulated stimulation near the surgical site and reported greater reductions in pain compared with sham treatment.[43] Skin irritation under the electrodes was noted in 1 participant. One study with low risk of bias examined the effects of transcutaneous nerve stimulation.[41] When compared with placebo transcutaneous nerve stimulation, less pain with knee extension and lower pressure pain threshold at the knee was reported. When compared with no intervention, less pain with knee extension and with gait was reported. One study with low risk of bias reported nonsignificant results for the effect of transcranial direct current stimulation over sham treatment on pain and mood.[36] No adverse events were reported.

"Physical Therapy" Interventions

Thirty-one studies (excluding the systematic reviews) clearly combined some form of "physical therapy" or exercise intervention with the intervention under study,[18-20,23-33,35,38,40-46,48,49,52-57] and in most of those studies, a comparison group received similar physical therapy interventions.[19,20,23-33,35,38,40-42,44-46,48,49,52-57] Of those studies, 15 reported statistically significant results for at least one of the outcome measures.[20,23,24,27,29-31,35,40,41,43,44,49,53,54] The actual type, intensity, and duration of physical therapy interventions were not clearly stated in many of the studies. Twenty-seven studies included gait training as part of the intervention[18-20,23-28,30-32,35,38,40,42,44-46,48,49,52-57]; 14 reported including transfer training[19,20,27,30,42,44-46,52-57]; 22 studies included active ROM exercises of the operative knee[18-20,26,27,30,32,35,38,42,44-46,48,49,52-57]; and 9 reported passive ROM of the knee[18,19,31,38,40,42,44,46,52] as part of the intervention. Four studies examined the effect of the same program of physical therapy intervention initiated at an earlier time postoperatively than the comparison group, or offered more often than in the comparison group.[19,23,52,53] Three studies reported starting some form of physical therapy intervention within 24 hours of surgery.[19,40,53] Sixteen studies included physical therapy interventions on "POD 1."[18-20,23,26,27,29-33,38,42,44,49,52,54,56] All studies reporting the frequency of physical therapy interventions included 1 to 2 times per day.

DISCUSSION

Principal Findings

Our search resulted in very few randomized clinical trials or systematic reviews with low risk of bias that addressed our question. We found insufficient evidence for the effectiveness of most of the interventions examined in the various studies. Results of 2 systematic reviews suggest that cryotherapy may reduce early postoperative pain and improve ROM; however, the authors of both systematic reviews noted that the level of evidence supporting their conclusion was very low.[50,51] We found very low level of evidence supporting early or enhanced rehabilitation to improve knee ROM and walking ability and reduce length of stay. The 5 studies supporting this conclusion comprised only 2 randomized controlled trials.[40,53] The other studies included retrospective data analyses,[23] comparison with a historic sample,[25] or lacked true randomization.[24] We also found very low level evidence for the use of neurostimulation for reduction of pain when electrodes were placed near the surgical site.

Possible Explanations

A majority of studies stated that the participants in both the intervention and comparison groups received some form of physical therapy or rehabilitation intervention, and in a majority of studies, such interventions were noted to start within 1 POD. Possibly, the lack of evidence for the effectiveness of most of the studied interventions is due to similar management of the intervention and comparison groups, and that changes in the outcomes studied are largely effected by various forms of interventions suggested by the term "physical therapy" or "standard care." In addition, all study participants likely received medical pain management of some type. One plausible explanation is that combined mobility and pain management, regardless of the form, are responsible for positive changes in function and activity during the acute postoperative phase of TKA. Another factor resulting in nonsignificant results may be the very short lengths of stay in the acute care setting, resulting in small changes and thereby, small differences between groups in the outcomes. One final factor is that research in the acute care setting can be extremely challenging because of the difficulty controlling for all the variables that may influence outcomes that affect function.

Strengths and Weaknesses of the Study

To our knowledge, this is the first systematic review of literature that addresses the effects of physical therapy interventions for patients with TKA, specifically in the acute care setting. The literature review was conducted by a team of reviewers with both research and clinical expertise, and the search process was supported by a skilled medical librarian. Outcomes that were not directly related to impairments of physical function or restriction in activities or participation were not examined. For example, some studies or data that were excluded reported amount of pain medication, amount of wound drainage, or other such medical outcomes that may have been affected by the interventions. We also examined literature over the past 20 years, a period in which significant changes in surgical procedures and pain management have occurred, positively affecting outcomes for all patients regardless of postoperative management. Risk of bias may be assessed in a variety of ways and a variety of terms may be used. We chose to provide qualitative descriptions of the risks of bias based on categories of potential bias.[58] A different approach may have resulted in differing assessments.

Limitations of this study include the fact that only studies reported in English were reviewed. Also, authors were not contacted to determine the existence of unpublished data. Only studies found in peer-reviewed literature and that were available in full text were included. The search was not limited to randomized controlled trials; however, studies that were not randomized controlled trials were assessed as having a

higher risk of bias. This search was limited to 3 major databases and we may have possibly missed relevant articles published in nonindexed journals; however, a skilled medical librarian was part of our review team, enhancing the probability that this search was effective. Because of the heterogeneous nature of the studies in terms of methods, interventions, and outcomes, a meta-analysis was not performed.

Clinical Implications

For patients with TKA in the acute care setting, very low-level evidence supports (1) cryotherapy early in the postoperative phase for reducing pain over other physical therapy interventions; (2) early, aggressive mobility interventions for improving ROM and walking ability rather than less aggressive approach; and (3) neurostimulation for reduction of pain over placebo or no neurostimulation. However, the effect of these interventions is uncertain due to the limitations of the studies. The evidence is insufficient to support any of the other intervention over a variety of comparison treatments. Given the state of the evidence, physical therapists will need to rely on empirical evidence and physiologically plausible rationale for selecting type, intensity, frequency, and duration of interventions. In addition, given the likely symbiotic relationship between pain management and physical therapy interventions, peri- and postoperative medical management may have important effects on the immediate gains in patients' function after TKA that cannot be separated from the effects of interventions provided by physical therapists.

Implications for Future Research

More rigorous randomized controlled trials and better organized studies are needed in which the intervention and comparison groups receive treatments that do not have so much in common, such as CPM or exercise. Such an approach may be difficult, given that exercise and mobility intervention are commonly viewed as standard care for individuals following TKA. In addition, to improve reproducibility of results, studies must include a more detailed description of the interventions reported as "physical therapy" or "standard care." Tracking the degree of improvement related to interventions is also important in future studies. This would allow for comparisons of interventions and analysis of the effect size of the intervention relative to the main outcomes found in the literature. This would help therapists select and prioritize treatments.

Furthermore, longer-term outcome studies with reports of the interventions from the acute care setting are needed. Finally, because the outcomes after TKA in the acute care setting are likely the result of multiple types of interventions provided by physicians, nurses, and rehabilitation professionals, studies must control for these factors in a systematic manner. Future research should include studies of units dedicated to care of patients with TKA, timing of rehabilitation interventions, day of surgery interventions, and functional targets and goals necessary to achieve prior to hospital discharge. All of these may directly effect the patient's early discharge from the acute care setting and are independent of the surgical advances in this population.

CONCLUSION

This systematic review of literature indicates very low-level evidence that supports (1) cryotherapy for reducing pain, (2) accelerated rehabilitation for improving ROM and walking, and (3) neurostimulation for reduction of pain in the acute care setting after TKA.

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