Evidence Synthesis Program

Interventions to Improve Long-term Adherence to Physical Rehabilitation Among Those with Hip or Knee Osteoarthritis or Chronic Low Back Pain: A Systematic Review

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PREFACE

The VA Evidence Synthesis Program (ESP) was established in 2007 to provide timely and accurate syntheses of targeted health care topics of importance to clinicians, managers, and policymakers as they work to improve the health and health care of Veterans. These reports help:

- Develop clinical policies informed by evidence;
- Implement effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
- Set the direction for future research to address gaps in clinical knowledge.

The program comprises four ESP Centers across the US and a Coordinating Center located in Portland, Oregon. Center Directors are VA clinicians and recognized leaders in the field of evidence synthesis with close ties to the AHRQ Evidence-based Practice Center Program. The Coordinating Center was created to manage program operations, ensure methodological consistency and quality of products, interface with stakeholders, and address urgent evidence needs. To ensure responsiveness to the needs of decision-makers, the program is governed by a Steering Committee composed of health system leadership and researchers. The program solicits nominations for review topics several times a year via the program website.

The present report was developed in response to a request from the Rehabilitation Research & Development Service (RR&D). The scope was further developed with input from Operational Partners (below), the ESP Coordinating Center, the review team, and the technical expert panel (TEP). The ESP consulted several technical and content experts in designing the research questions and review methodology. In seeking broad expertise and perspectives, divergent and conflicting opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Ultimately, however, research questions, design, methodologic approaches, and/or conclusions of the review may not necessarily represent the views of individual technical and content experts.

ACKNOWLEDGMENTS

The authors are grateful to Liz Wing and Stacy Lavin for editorial and citation management support, and the following individuals for their contributions to this project:

Operational Partners

Operational partners are system-level stakeholders who help ensure relevance of the review topic to the VA, contribute to the development of and approve final project scope and timeframe for completion, provide feedback on the draft report, and provide consultation on strategies for dissemination of the report to the field and relevant groups.

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Technical Expert Panel

To ensure robust, scientifically relevant work, the TEP guides topic refinement; provides input on key questions and eligibility criteria, advising on substantive issues or possibly overlooked areas of research; assures VA relevance; and provides feedback on work in progress. TEP members are listed below:

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The Coordinating Center sought input from external peer reviewers to review the draft report and provide feedback on the objectives, scope, methods used, perception of bias, and omitted evidence (see Appendix E for disposition of comments). Peer reviewers must disclose any relevant financial or non-financial conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The Coordinating Center works to balance, manage, or mitigate any potential non-financial conflicts of interest identified.

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ABBREVIATIONS TABLE

Abbreviation	Definition
BCT	Behavior change technique
CBT	Cognitive behavior therapy
CI	Confidence interval
COE	Certainty of evidence
COM-B	Capability, opportunity, and motivation
ESP	Evidence Synthesis Program
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
KOOS	Knee and Osteoarthritis Outcome Score
KQ	Key question
LBP	Low back pain
NRS	Numeric rating scale
OA	Osteoarthritis
OECD	Organisation for Economic Co-operation and Development
OR	Odds ratio
PRESS	Peer Review of Electronic Search Strategies
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta Analyses
PT	Physical therapy
ROB	Risk of bias
RR&D	Rehabilitation Research and Development
SD	Standard deviation
SEE	Self-Efficacy for Exercise Scale
SMD	Standardized mean difference
VHA	Veterans Health Administration
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index

EVIDENCE REPORT

INTRODUCTION

PURPOSE

The Evidence Synthesis Program (ESP) is responding to a request from the Rehabilitation Research and Development Service (RR&D). Findings from this review will be used to inform future research on adjunct interventions to promote long-term adherence to physical rehabilitation recommendations.

BACKGROUND

Chronic pain, with musculoskeletal dysfunction as a common cause, results in over $600 billion of US health care spending annually—exceeding costs for other highly prevalent conditions like heart disease, cancer, and diabetes.[1] Chronic low back pain (LBP), specifically, fell into the highest category of national health care spending in 2016.[2] In the Veterans Health Administration (VHA), 25% of patients with musculoskeletal conditions receive care for LBP annually, and an additional 21% of Veterans receiving musculoskeletal care have osteoarthritis (OA). One approach to managing the symptoms of these chronic conditions is physical rehabilitation. Physical rehabilitation interventions use tailored exercise and activity to improve clinical outcomes for individuals with chronic LBP and OA, reducing pain and disability in these populations.[3,4] Despite the effectiveness of rehabilitation, adherence to rehabilitation interventions has been measured as low as 13%. Poor adherence is a concern especially when the patient is no longer under direct clinical supervision.[5,6]

Adjunct interventions have been proposed to address low rates of long-term adherence to musculoskeletal rehabilitation by targeting the maintenance of, rather than initiation of, behavior change required for long-term success.[7] Examples of adjuncts include psychological interventions (*eg*, cognitive behavioral therapy and motivational interviewing) and performance feedback interventions (*eg,* coaching, peer support, activity tracking[8]). However, it is currently unknown which of these adjunct interventions have the greatest impact on patient motivation, long-term adherence to rehabilitation, or ultimate physical function outcomes. This is largely due to a pervasive disconnect between components of behavior change interventions and the underlying mechanisms of behavior change (capability, opportunity, and motivation).[9] Thus, there is an opportunity to improve long-term patient rehabilitation outcomes by applying current behavior change science—codified in the standardized, evidence-based behavior change technique (BCT) taxonomy[10]—to the analysis and design of long-term adherence interventions.

Promoting long-term physical function and quality of life in Veterans through evidence-based practice is a core goal of the VHA, and improving long-term adherence to rehabilitation for those with chronic musculoskeletal conditions has the potential to significantly delay or prevent severe forms of disease and disability.[11] Thus, the aim of this review is to evaluate the impact of physical rehabilitation interventions supplemented with 1 or more adherence-focused adjunct components, on the following outcomes among adults with hip or knee OA or chronic LBP: (1) adherence, (2) functional improvements, and (3) self-efficacy at ≥ 3 months after completing an index rehabilitation program. As part of our analysis, we seek to provide insights into how future interventions might be optimized through the selection of BCTs that maximize patient benefit.

METHODS

TOPIC DEVELOPMENT

This topic was requested by the VA Rehabilitation Research & Development Service (RR&D). The findings from this review will be used to inform the development of a new request for applications on adjunct interventions that promote long-term adherence to physical rehabilitation recommendations. This review may also inform rehabilitation clinicians and program leadership who seek to improve the long-term outcomes for patients with chronic musculoskeletal pain and functional impairment.

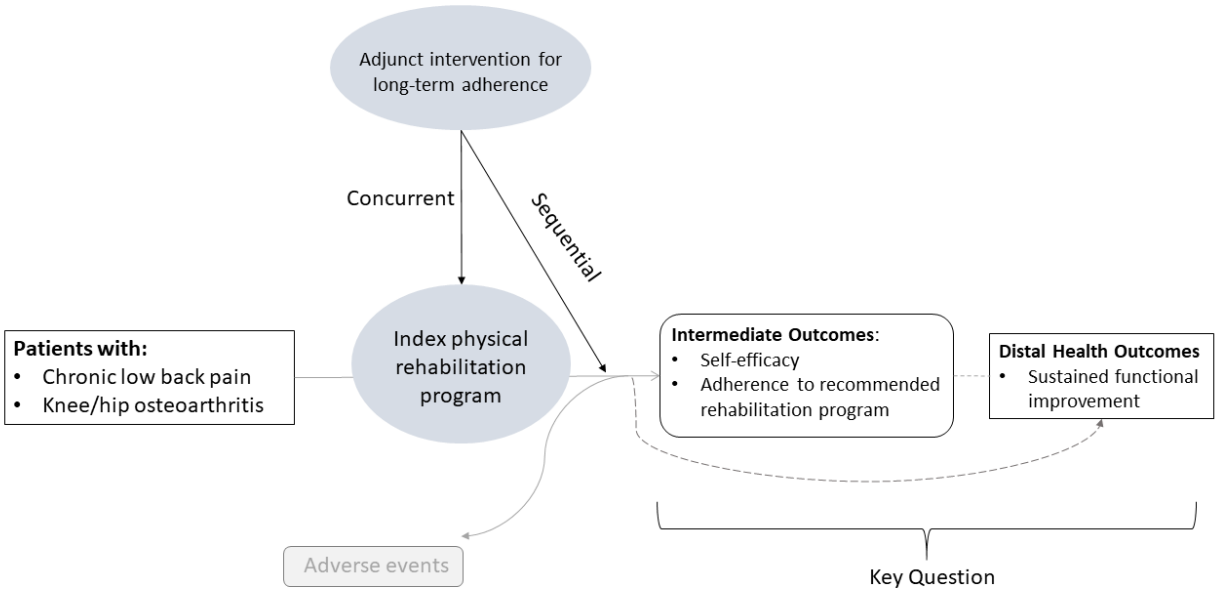
KEY QUESTION

The following key question (KQ) was the focus of this review: *Among adults with hip/knee osteoarthritis or chronic low back pain, do physical rehabilitation interventions, supplemented with 1 or more adjunct components to promote adherence, improve self-efficacy, adherence, or sustained functional improvements at ≥3 months after completing the rehabilitation program?*

ANALYTIC FRAMEWORK

The analytic framework shown in Figure 1 provides a conceptual overview of this review. For adults with hip/knee OA or chronic LBP who engage in physical therapy and rehabilitation programs, the goal is to experience sustained functional improvements. It is generally thought that in order to sustain these functional improvements over time, patients need to demonstrate a long-term commitment to the practice of the prescribed home exercise program. However, long-term adherence to prescribed home exercise is often a struggle for many individuals. Thus, there is the potential for interventions that promote long-term adherence to be delivered as an adjunct to a standard rehabilitation program delivered either at the same time as the initial, or index, rehabilitation program (*ie*, concurrently) or after the end of the index program (*ie*, sequentially). An expected intermediate outcome of adjunct interventions that promote long-term adherence is increased self-efficacy to complete the home exercise program as prescribed. We also recognize that it is possible that there could be adverse effects from the addition of adjunct adherence interventions to rehabilitation programs, though we expect such effects to be rare. The analytic framework depicted in Figure 1 is a visual representation of the context for this report and highlights the intermediate and long-term outcomes of interest.

Figure 1. Analytic Framework



DEFINITIONS

To guide our review process and reporting of findings, we established the following definitions:

- Index rehabilitation program is the initial physical rehabilitation care (*ie*, active, structured physical activity or activities designed to reduce impairments and improve movement-related function) that is delivered, supervised, and/or monitored by a health care professional or other trained individual.
- Adjunct adherence-enhancing intervention is the supplemental component provided to the patient in addition to the index rehabilitation program (either concurrent with or sequential to) that is designed to promote long-term adherence to the prescribed home rehabilitation practice.

PROTOCOL

A preregistered protocol for this review can be found on the PROSPERO international prospective register of systematic reviews (http://www.crd.york.ac.uk/PROSPERO/; registration number CRD42021276794). There were no significant deviations after submission of this protocol. In addition, we followed the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guideline.[12]

DATA SOURCES AND SEARCHES

To identify primary literature that addresses our key question, we conducted a primary search from inception to July 27, 2021, in MEDLINE (via Ovid), CINAHL Complete (via EBSCO), and Embase (via Elsevier). We used database-specific controlled vocabulary as well as relevant keywords to search titles and abstracts (see Appendix A for complete search strategies). To

ensure completeness, our search strategies were developed by an expert medical librarian (SC) with input on key terms from subject matter experts. We identified exemplar articles to use to test the integrity of our developed search strategy prior to executing across all databases. All search strategies were reviewed by a second medical librarian in accordance with the Peer Review of Electronic Search Strategies (PRESS) guideline.[13]

STUDY SELECTION

Studies identified through our primary search were classified independently by investigators for relevance to the KQ based on our eligibility criteria (Table 1). All citations classified for possible inclusion based on title and abstract by at least 1 investigator underwent full-text review. Citations designated for exclusion by 1 investigator at the title-and-abstract level underwent screening by a second investigator. The study was excluded if both investigators agreed on exclusion. All articles reviewed during full-text review were evaluated independently by 2 investigators, and all articles meeting eligibility criteria were included for data abstraction. All articles were tracked in both DistillerSR, a web-based data synthesis software program (Evidence Partners Inc., Manotick, ON, Canada), and EndNote reference management software (Clarivate).

Eligibility Criteria

Our review included studies that met the criteria shown in Table 1.

Table 1. Study Eligibility

	Inclusion	Exclusion
Populations	Adults (age 18 years+) with: • Hip or knee osteoarthritis (self-reported diagnosis, clinical criteria, or radiographic evidence) • Chronic low back pain (lasting ≥12 weeks)[14]	• <75% participants with hip or knee OA and/or chronic low back pain • Patients with OA of hip/knee who are within 12 months before or after joint surgery
Interventions	Physical rehabilitation interventions (*ie*, active, structured physical activity or activities designed to reduce impairments and improve movement-related function that is delivered, supervised, and/or monitored by a health care professional *or other trained individual*) that have an adjunct component(s) (embedded within initial physical rehabilitation) or are followed by component(s) (delivered after initial physical rehabilitation) designed to promote long-term adherence to the prescribed rehabilitation home practice including but not limited to the following approaches: • Feedback and monitoring (*eg,* use of activity monitors, automated text messages) • Social support (*eg,* peer coaches) • Incentives	Interventions focused on adherence to prescribed activities during initial rehabilitation treatment only Interventions focused on perioperative rehabilitation for knee or hip replacement or other surgery

	Inclusion	Exclusion
	• Psychologically informed interactions (*eg,* cognitive behavioral therapy, acceptance and commitment therapy, motivational interviewing) Initial rehabilitation intervention must be delivered by trained individuals (in-person or virtual) with clearly stated profession (*eg,* PTs, kinesiotherapists, certified exercise physiologist, physiatrist [rehabilitation MD]) Adherence-focused sessions/component delivered in addition to the core physical rehabilitation treatment may be delivered by individuals other than those who delivered the original physical rehabilitation treatment Interventions may involve caregiver, but primary target of intervention must be the patient	
Comparators	Same initial physical rehabilitation intervention without the adjunct component or same initial physical rehabilitation with attention control instead of adjunct component	No comparator, other active comparator
Outcome	Any of the following if measured at 3 or more months after the end of the initial rehabilitation intervention: • Self-efficacy to engage in home practice of physical rehabilitation outside of supervised physical rehabilitation • Adherence to prescribed rehabilitation home practice NOTE: *If study does not explicitly describe an intent to promote long-term adherence to rehabilitation home practice, it must measure adherence as an outcome*. • Measures of physical function (including but not limited to WHO-DAS, FIM + FAM, 6-minute walk test) • Adverse events (*eg*, falls, fractures, ED visits)	Any outcomes without at least 1 of those listed under inclusion
Setting	Initial physical rehabilitation intervention: clinic or home-based Adjunct component: in-person, home-based, remotely delivered)	Inpatient settings
Timing	At least 2 contacts for initial physical rehabilitation intervention	Not applicable

	Inclusion	Exclusion
Study design	• Randomized trials • Non-randomized trials	• Not a clinical study (*eg,* editorial, letter to an editor) • Uncontrolled clinical study • Qualitative studies • Prospective or retrospective observational studies • Systematic review/meta-analysis • Clinical guidelines • Measurement or validation studies
Countries	OECD[a]	Non-OECD
Publication types	Full publication in a peer-reviewed journal	Letters, editorials, reviews, dissertations, meeting abstracts, protocols without results

Notes. [a] OECD includes Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.
Abbreviations. ED=emergency department; FIM + FAM=Functional Independence Measure and Functional Assessment Measure; OA=osteoarthritis; OECD=Organisation for Economic Co-operation and Development; PT= Physical Therapist; WHO-DAS=World Health Organization Short Disability Assessment Schedule.

DATA ABSTRACTION AND ASSESSMENT

Data from published reports were abstracted into a customized DistillerSR database by 1 reviewer and over-read by a second reviewer. Disagreements were resolved by consensus. Abstracted data elements included participant descriptors (*eg*, age, sex, race/ethnicity, Veteran status), intervention characteristics (*eg*, interventionist profession, duration of index rehabilitation program, content and mode of both index rehabilitation program and adjunct component, whether adjunct component was delivered concurrently or in series to the initial index rehabilitation treatment course), comparator, and outcomes (*eg*, which outcome was identified as the primary outcome of the study). Multiple published reports analyzing data obtained from a single study were treated as a single data point with the most relevant results drawn across reports. When critical data were missing or unclear in published reports, we requested supplemental data from the study authors. For details of study characteristics, see Appendix B. Appendix C presents details of the intervention characteristics. Appendix D lists excluded studies and the reason for exclusion.

Quality assessment was completed in duplicate by 2 investigators (the investigator who abstracted the included article and the investigator who over-read the abstraction data). Disagreements were resolved by consensus between those 2 investigators or, as needed, by arbitration by a third investigator. We used the revised Cochrane Risk of Bias for randomized trials and cluster randomized trials (RoB 2)[15] and the ROBINS-I for non-randomized studies.[16] The domains for the RoB 2 include (1) bias arising from randomization process; (2) deviations from intended intervention; (3) missing outcome data; (4) bias in measurement of the outcome; and (5) bias in selection of the reported results. Overall risk of bias (ROB) judgments included low ROB, some concerns, and high ROB. Cluster-randomized studies were evaluated additionally for bias arising from the timing of identification and recruitment of individual

participants in relation to timing of randomization. The ROBINS-I includes domains for (1) confounding; (2) participant selection; (3) intervention classification; (4) deviations from intended interventions; (5) missing data; (6) outcome measurement; and (7) selective outcome reporting. Overall ROB judgments included low ROB, serious ROB, critical ROB, and no information.

SYNTHESIS

First, we summarized the following key study characteristics of the included studies: study design, patient demographics, details of the index rehabilitation program, adjunct adherence intervention and comparator, outcomes measures, and timing of outcomes assessment. We considered the feasibility of completing a quantitative synthesis (*ie*, meta-analysis) to estimate summary effects. For meta-analyses, feasibility depends on the volume of relevant literature, conceptual homogeneity of the studies, and completeness of results reporting. Because of incomparability in intervention characteristics (*eg,* training for physical therapists in communication skills vs text message exercise reminders to patients) and delivery methods (*eg,* in-person vs automated), as well as inconsistency in outcome measurement, we did not conduct meta-analyses.

As an alternative to meta-analyses, we calculated the standardized mean difference (SMD) for studies reporting similar outcome categories (*eg,* functional status using a validated tool) when possible. Standardized mean differences for functional outcomes were calculated as the difference in mean change from the end of rehabilitation program between arms (intervention minus control) divided by the pooled standard deviation across the arms. When mean change was not reported by a study, we used difference between means at 2 time points and considered 0.5 correlation between measurements at these 2 time points to compute standard deviation of change. When values at the end of the rehabilitation program were not directly provided by a study, we computed these values based on the baseline mean values and reported mean change from baseline. Standardized mean differences for adherence outcomes were calculated as difference between arms (intervention minus control) at the time of follow-up measurement divided by the pooled standard deviation across the arms.

The follow-up timepoints of interest for this review are limited to outcomes at ≥ 3 months after completing the index rehabilitation program. We estimated the time point of each outcome measurement as time since baseline minus the time since end of the rehabilitation program (*eg*, data at 6 months after baseline is the same as data collected 3 months after a 3-month intervention). In cases where the study performed a second round of randomization after the end of the rehabilitation program and before implementation of adjunct adherence components, outcome time points are not changed, as baseline and end of the rehabilitation program are the same.

Because quantitative synthesis was not feasible, we analyzed data narratively through descriptive approaches that identify patterns in key outcomes, comparators, intervention approaches, and other study characteristics. We gave more weight to the evidence from higher quality studies with more precise estimates of effect. The narrative synthesis focused on documenting and identifying patterns in efficacy across included studies by outcome category (*ie,* adherence, functional status, self-efficacy, and adverse events). We analyzed potential reasons for

inconsistency in treatment effects across studies by evaluating differences in the study population, intervention, comparator, and outcome definitions.

In addition, for each included study, we coded BCTs used in all experimental and control arms using a BCT taxonomy (v1)[10] derived from information presented in included studies and any published protocols we identified. Two experienced reviewers (KS and ZR) independently coded each study for BCTs. Any discrepancies were resolved through discussion. A third author (KG) was consulted if needed.

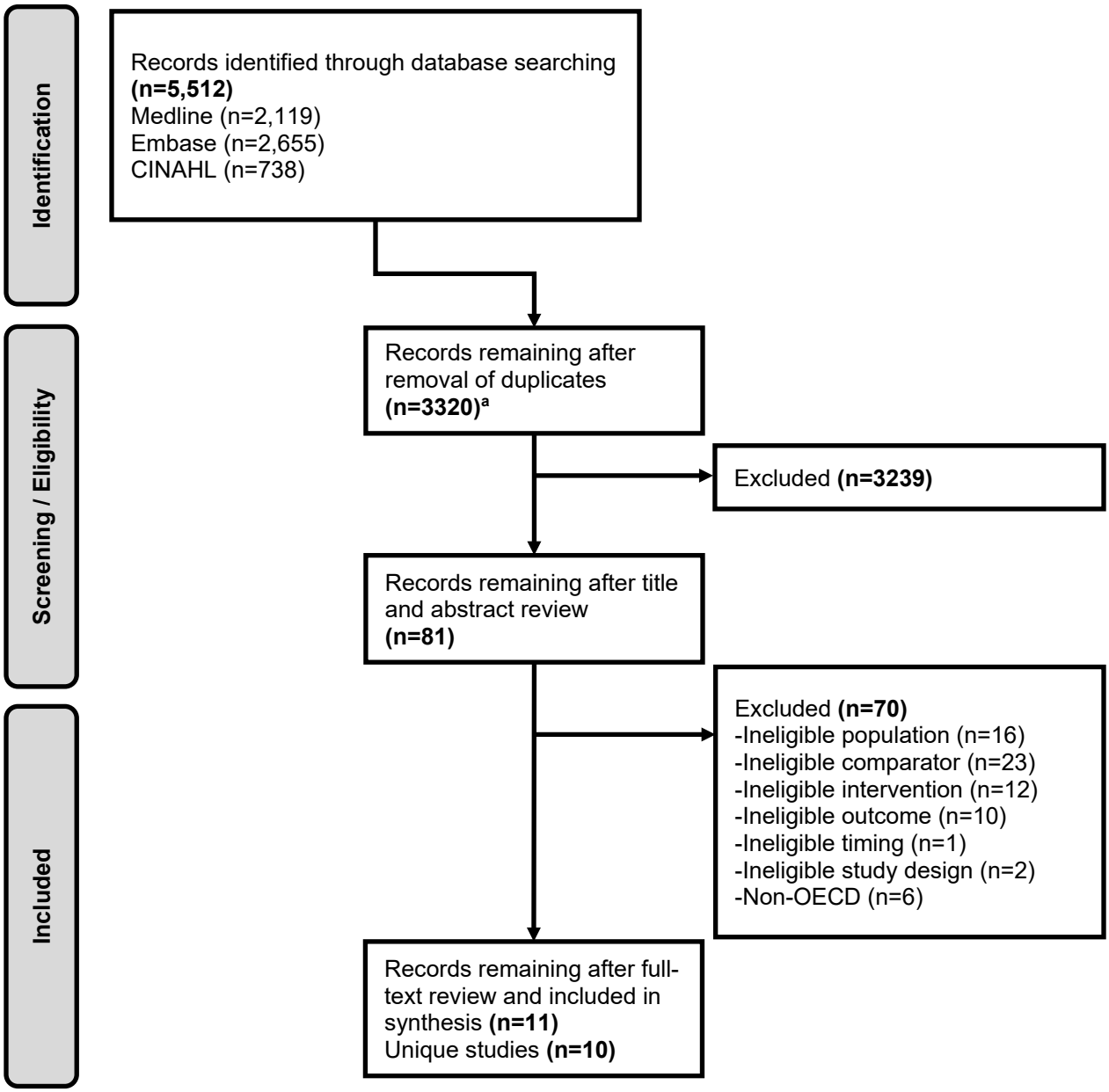
Finally, the certainty of evidence (COE) was assessed using the approach described by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) working group.[17] GRADE criteria require assessment of 4 domains: risk of bias, consistency, directness, and precision. Additional domains to be used when appropriate are coherence, dose-response association, impact of plausible residual confounders, strength of association (magnitude of effect), and publication bias. These domains were considered qualitatively, and a summary rating was assigned after discussion by a group of investigators (ZR, KS, KG, AG) as high, moderate, low, or very low COE. Randomized and non-randomized designs were not combined per GRADE guidance. Studies reporting dichotomous outcomes were not combined with studies reporting continuous outcomes.

RESULTS

LITERATURE FLOW

The literature flow diagram (Figure 2) summarizes the results of the study selection process (full list of excluded studies available in Appendix D).

Figure 2. Literature Flowchart



Notes. [a] Search results from Medline (2,108), Embase (1,111), and CINAHL (101) were combined.

LITERATURE OVERVIEW

Our search identified 3,320 potentially relevant articles. After removing duplicates, there were a total of 3,320 articles. After applying inclusion and exclusion criteria to titles and abstracts, 81 articles remained for full-text review. Of these, 11 studies (10 unique) were retained for data abstraction, including 1 non-randomized trial, 2 cluster randomized trials, and 7 randomized controlled trials. None were conducted in the VA. The studies were conducted in the United States (1), Canada (1), Australia (3), Europe (4), and Israel (1) (Table 2).

Table 2. Evidence Profile of Included Studies

Number of studies: 11 studies (10 unique interventions)
Study Designs: Cluster randomized controlled trial (n=2); Individual randomized controlled trial (n=7); non-randomized controlled trial (n=1)
Number of participants: 1,964
Countries: Europe (n=4); Australia (n=3); USA (n=1); Canada (n=1); Israel (n=1)
Patient demographics (median): age = 62 years old; women (63%); White (74%) (6 studies not reported), Black (2.3%) (9 studies not reported)
Conditions: Knee osteoarthritis (n=5); Low back pain (n=3); Hip osteoarthritis (n=1); Knee and Hip osteoarthritis (n=1)
BCT components: Mean number of BCTs per index rehabilitation program = 8.8 (range 5 BCTs to 11 BCTs) and mean number of BCTs per adherence adjunct intervention= 6.2 (range 2 BCTs to 15 BCTs)
Duration of index rehabilitation program: Median duration was 3 months (range 1 month to 12 months)
Duration of adherence adjunct: Median duration was 6 months (range 1 month to 24 months)
Intervention timing: Concurrent (n=6); Sequential (n= 4)
Risk of bias: Low (n=4); Some concerns (n=2); High (n=4)[a]; Serious (n=1)[b]

Notes. [a] One study was evaluated as low risk of bias for objectively measured outcomes and high risk of bias for patient reported outcomes.[18] [b] ROBINS-I tool was used to evaluate the non-randomized controlled trial.[19]
Abbreviations. BCT=behavior change technique.

MAIN FINDINGS

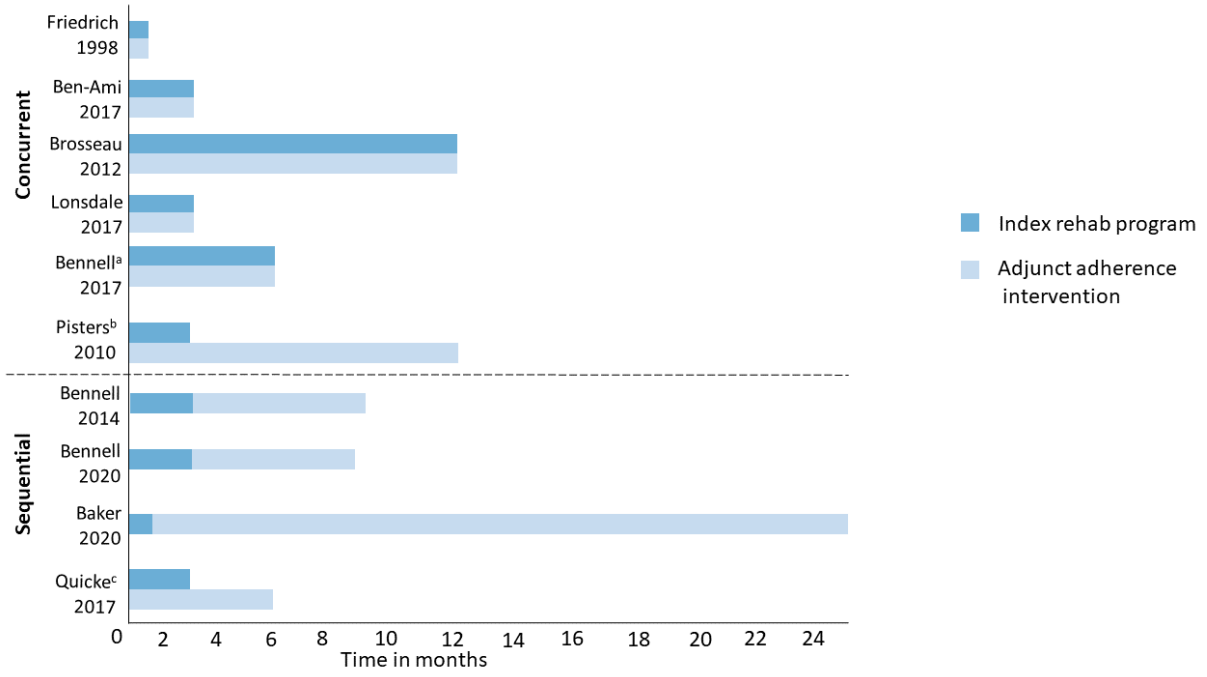
Key Points

- We identified 10 studies evaluating adjunct adherence interventions: 6 delivered concurrently to an index rehabilitation program and 4 delivered sequentially.
- Most studies targeted patients with knee and/or hip OA (7 studies).
- There was often similarity in the behavior change techniques used in intervention and comparator groups, and no studies provided a rationale for this overlap.
- Included studies were generally small and only 5 articulated a specific intent to promote long-term adherence.
- Of the 3 studies that reported a positive effect on long-term adherence, only 1 was a low ROB study.
- Included studies with notable limitations showed no meaningful treatment effect on long-term physical function.

Intervention Characteristics

Of the 10 unique studies included in this review, 4 featured a sequentially delivered adjunct adherence intervention[20-23] and 6 were delivered concurrently to the index rehabilitation program[18,19,24-27] (Figure 3). All but 1 study[18] included some form of traditional physical therapy as the index rehabilitation program, though they varied in duration (1.5 to 6 months) and type (*eg*, submaximal graded exercise program, strength training). The number of physical rehabilitation sessions (median = 5, range = 2–156) also varied widely across the included studies. The duration of individual sessions and dose actually delivered to patients (*eg,* sessions attended) were not regularly reported in these studies. Five studies[18,20,21,24,26] explicitly focused on improving adherence to rehabilitation or home practice or reported adherence as a primary outcome. Five adjunct interventions[18,20-22,25] were conducted at least partially remotely (*eg*, telephone, text message). No studies reported using video for adjunct adherence support. The median duration of the adjunct component was 6 months (range = 1–24 months) and the number of sessions ranged from 2 to 42 with a median of 7 sessions. All but 1 study[18] reported the profession of the provider delivering the adjunct adherence intervention, and all were physical therapists or similarly trained clinicians. Little detail was provided about the training or experience of interventions. Below, we describe the concurrent and sequential adjunct interventions in more detail.

Figure 3. Timing of Rehabilitation and Adjunct Interventions



Notes. [a] Participants in the intervention could receive up to 6 extra coaching telephone sessions after the end of the index rehabilitation program. [b] The adjunct components were intentionally different during the same timeframe as the rehabilitation program and determined to be concurrent. [c] The majority of the unique adjunct components were delivered after the rehabilitation program was completed.

Concurrently Delivered Adjunct Adherence Interventions

Three concurrently delivered adjunct interventions targeted chronic LBP, 2 focused on knee OA alone, and 1 studied hip and/or knee OA.[19,24,27] All 3 studies focused on the treatment of chronic LBP, included specific provider training, or offered treatment approaches as an integrated component of the index rehabilitation program. Specifically, they provided communication training for physical therapists based on self-determination theory[24] (a transtheoretical, model-informed rehabilitation counseling intervention[19]) and a motivational program co-delivered with a standard rehabilitation program.[27,28] Two concurrent interventions for patients with hip or knee OA were aligned with more traditional rehabilitation programs. One provided 6 CBT-informed telephone counseling sessions as a supplement during—and then up to an 6 additional sessions after—a standard progressive individualized home rehabilitation program.[25] The other provided a behavioral-graded activity intervention with an additional 7 booster sessions beyond the end of the index rehabilitation program.[26] Finally, 1 knee OA program consisted of a supervised community walking program supplemented by concurrent group sessions focused on goal setting and support provision.[18]

Sequentially Delivered Adjunct Adherence Interventions

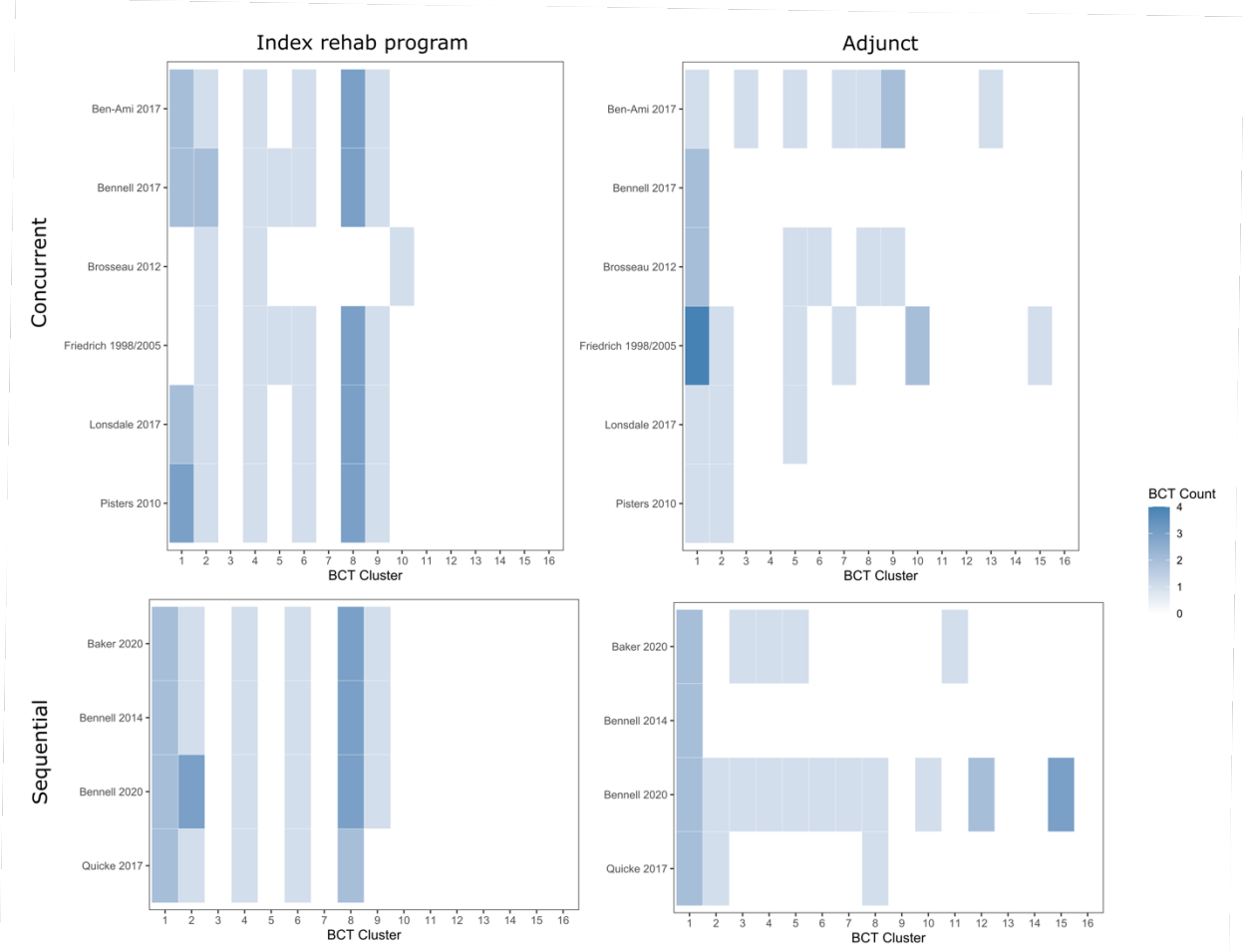
All 4 sequentially delivered adjunct adherence intervention studies targeted patients with knee OA. Two with the same lead author were developed as add-on studies recruiting participants who had completed prior physical therapy trials;[20,23] the first provided 2 additional booster physical therapy (PT) sessions over the 24 weeks after index rehabilitation,[23] and the second provided 24 weeks of automated, semi-interactive text messages after index rehabilitation.[20]

Baker et al[21] provided monthly motivational adherence counseling calls for 18 months after a run-in period of a strength training rehabilitation program, and Quicke et al provided an adherence toolkit including tools for self-monitoring and follow-up adherence sessions.[22] See Appendix C for additional intervention details.

Behavior Change Techniques

We identified BCTs targeting adherence to prescribed physical rehabilitation interventions for each study, including for both the intervention and comparator arms (Appendix F). A total of 38 of the total 93 BCTs from the BCT taxonomy (v1)[10] were identified across the included studies, representing 14 of the 16 BCT clusters (see Appendix G). The number of BCTs in comparator arms ranged from 5 to 11 (mean = 8.8 BCTs), while intervention groups included 2 to 15 unique BCTs (mean = 6.2). Bennell et al[20] had the most unique BCTs in the adjunct adherence-enhancing intervention (15), followed by Friedrich et al[27] (10) (Figure 4). Of note, Bennell et al[20] was the only included study that specifically mentioned incorporation of BCTs and related theory during intervention development. BCTs commonly included in index rehabilitation programs reflect typical clinical practice (examples include goal setting, instruction on how to perform a behavior, demonstration of the behavior, and behavioral practice/rehearsal). Though 14 of 16 BCT clusters were represented across all 10 included studies, 10 BCT clusters were present in ≤ 3 adjunct adherence-enhancing interventions. Adjuncts that demonstrated improved long-term adherence tended to have more unique BCTs compared to those that did not improve adherence. Adjuncts that were delivered concurrently likewise tended to have fewer BCTs than those that were delivered sequentially. Across all included studies, little detail was available about how BCTs were operationalized within the clinical encounters.

Figure 4. Heatmap of BCTs Identified in Index Rehabilitation Programs and Adjunct Adherence Interventions

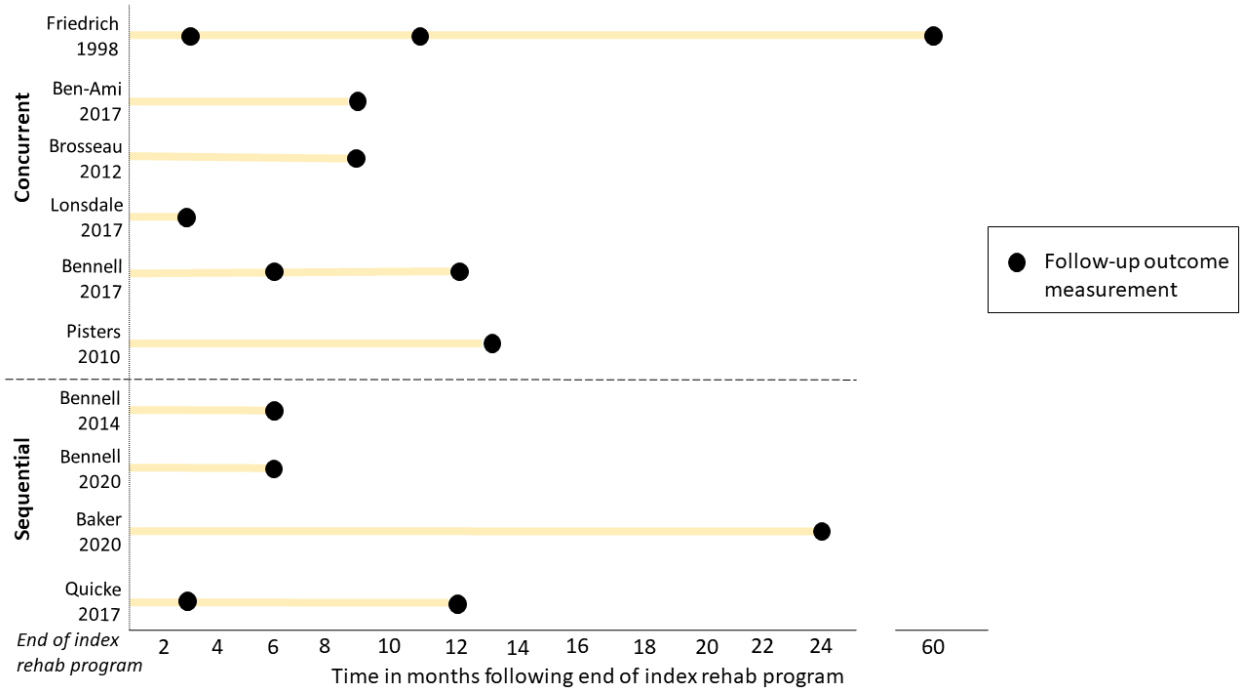


Notes. Behavior change techniques (BCTs) were categorized by count in each cluster and are presented in colors ranging from white to blue as shown in the key. BCT domains: 1. Goals and planning, 2. Feedback and monitoring, 3. Social support, 4. Shaping knowledge, 5. Natural consequences, 6. Comparison of behavior, 7. Associations, 8. Repetition and substitution, 9. Comparison of outcomes, 10. Reward and threat, 11. Regulation, 12. Antecedents, 13. Identity, 14. Scheduled consequences, 15. Self-belief, 16. Covert learning.

KEY OUTCOMES OF INTEREST

Included studies measured outcomes at a variety of time points. In Figure 5, we depict the timing of outcomes by study in relationship to the end of the index rehabilitation program in order to emphasize sustainment of outcome effects. For the rest of the results section, we refer to follow-up time points in this manner unless stated otherwise. Note that the primary study publications did not necessarily label assessment time points in this way. One study[23] reported standard deviation (SD) as a direct measure of change. For all other studies, we computed SDs of change from after treatment to follow-up assuming correlation of 0.5 between after-treatment SD and follow-up SD. For 2 studies,[19,24] we used mean change from baseline to after treatment and the baseline mean (and corresponding SDs) to compute after-treatment mean change and SDs (assuming 0.5 correlation between baseline and after-treatment measurements). For 1 study, we assumed the number of participants after 12 months of follow-up was the same as the number of participants reported at the end of treatment, as the exact number was not specified.[22]

Figure 5. Timeline of Outcome Reporting



Adherence to Prescribed Home Rehabilitation Program

Ten studies reported on long-term adherence outcomes.[18-27] Adherence to the prescribed home rehabilitation program was measured in multiple ways. Only 2 studies employed validated adherence scales; specifically, Ben-Ami et al used the Baecke PA questionnaire,[19] and Bennell et al 2020 used the Exercise Adherence Rating Scale.[20] An additional 6 studies reported adherence using unvalidated numeric rating scales (ranging from 5 to 11 points), though the specific prompt varied (Table 3).[20-25] Six studies assessed self-reported adherence through variations in percent completion of the prescribed home rehabilitation program or physical activity.[18,20,22-25] One study reported the proportion of adherent participants per study arm,[26] and 1 study reported the number of weeks participants reported being adherent after completion of the index rehabilitation program.[27] Adherence was measured at time points ranging from 3 months to 5 years after completion of the index rehabilitation program. Six studies measured adherence at only 1 relevant time point (ranging from 3 to 24 months after the end of the index rehabilitation program).[18-21,23,24]

Next, we report findings for adherence outcomes across studies that evaluated the effect of concurrent and then sequentially delivered adjunct interventions.

Concurrently Delivered Adjunct Adherence Interventions (N = 6)

Six studies evaluated the effect of concurrently delivered adjunct interventions reported on adherence to prescribed home rehabilitation programs.[18,19,24-27] Overall, there was no evidence of benefit with concurrently delivered adjunct interventions at 3 to 6 months (SMD range = 0.05–0.06) or 9 months and longer (SMD range = 0.06–0.20) among those studies with continuous outcome measures (Figures 6, 7, 8). The 1 low-ROB study by Bennell et al (2017) evaluated the concurrent delivery of 6 telephone-delivered coaching sessions with up to 6 additional sessions

delivered after index rehab.[25] Authors found no significant difference in adherence between intervention and comparator at 6 months post-rehab or 12 months as measured by self-rated adherence by NRS or percent prescribed home exercises completed. Lonsdale et al, the largest (albeit a high ROB) study with 207 participants with chronic LBP, found no effect of communication skills training for physical therapists on adherence at 3 months.[24] Finally, another serious-ROB study by Ben-Ami et al reported a mean difference of 0.7 (95% CI [0.07, 1.3]) on the validated Baecke Physical Activity Questionnaire (range = 1–5; higher = greater activity level) from baseline (pre-index rehab program) to 12 months post-baseline for patients with chronic LBP who had received a 3-month enhance transtheoretical model intervention versus usual care PT.[19] However, when the mean difference between arms at 9 months post-index rehabilitation was considered, there was no significant treatment effect (SMD = 0.20, 95% CI [-0.09, 0.48]; Figure 7).

Pisters et al, a study with some concerns for ROB, reported adherence as a dichotomous outcome (*ie*, being adherent to prescribed rehabilitation or not).[26] Authors evaluated 18 sessions of a behavioral rehabilitation program followed by 7 booster sessions compared to 18 sessions of usual PT care among 200 patients with hip/knee OA and reported a greater odds of participants being adherent to prescribed rehabilitation in the intervention group compared with usual care at 13 months post-index rehabilitation (OR = 3.0, 95% CI [1.5, 6.0]). The other concurrent studies not included in the forest plot were a high ROB studies.[18,28] One that reported similar means across study arms for adherence at 3 months, 11 months, and 5 years.[27] One reported no evidence of significant benefit at 9 months (Table 3).[18]

Sequentially Delivered Adjunct Adherence Interventions (N = 4)

Four studies (2 low, 1 some concerns, and 1 high ROB) with sequentially delivered adherence interventions reported adherence outcomes.[20-23] Overall, one low ROB study reported beneficial effects. Bennell et al, evaluated the effect of 24 weeks of automated, semi-interactive text messages delivered after index rehabilitation on adherence as measured by the validated Exercise Adherence Rating Scale (score range = 0–24; higher = better adherence) among 110 patients with knee OA.[20] They found higher rates of adherence at 6 months post-index rehabilitation with a mean difference of 3.1 (95% CI [0.8, 5.5]) and a mean difference of 0.6 (95% CI [0.2, 1.0]) additional days that home rehabilitation was completed in the last week. This translated to an SMD of 0.42 (95% CI [0.02, 0.82]). The other low ROB study, Bennell et al (2014), evaluated the sequential delivery of 2 PT booster sessions on 74 participants with knee OA over 24 weeks after index rehabilitation and found no significant effect on adherence (SMD = 0.18, 95% CI [-0.28, 0.63]).[23]

Of the other 2 studies with sequentially delivered interventions, 1 had some concerns for ROB,[22] and 1 had high ROB.[21] They reported no evidence of significant benefit at 24 months (Table 3).[21]

Table 3. Adherence to Prescribed Home Rehabilitation Program

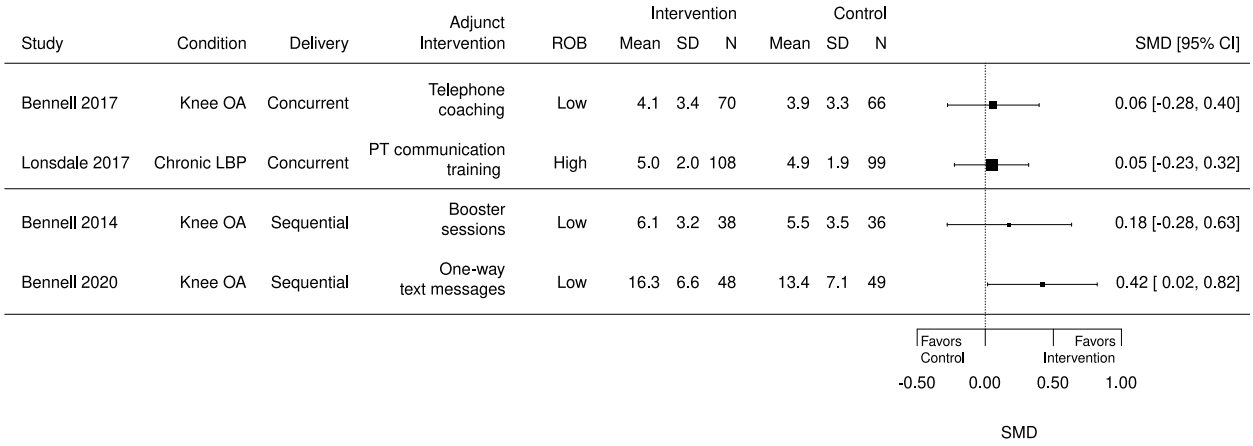
Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
Concurrent		
Bennell, 2017[25] **Low ROB**	6 months	*Home rehabilitation adherence (percentage of prescribed sessions completed)* Intervention mean = 42% (95% CI [34, 50]) Comparator mean = 39% (95% CI [31, 48]) Mean difference = 2% (95% CI [-10%, 14%]) *Self-rated home rehabilitation adherence into NRS* Intervention mean = 4.1 (95% CI [3.3, 4.9]) Comparator mean = 3.9 (95% CI [3.1, 4.7]) Mean difference = 0.2 (95% CI [-0.8, 1.3])
	12 months	*Home rehabilitation adherence (percentage of prescribed sessions completed)* Intervention mean = 39% (95% CI [31, 46]) Comparator mean = 37% (95% CI [28, 46]) Mean difference = 1% (95% CI [-10, 12]) *Self-rated home rehabilitation adherence into NRS* Intervention mean = 3.8 (95% CI [3.1, 4.6]) Comparator mean = 3.6 (95% CI [2.9, 4.4]) Mean difference = 0.2 (95% CI [-0.8, 1.2])
Pisters, 2010[26] **Some concerns about ROB**	13 months	*Self-rated questionnaire - adherence to rehabilitation* Intervention: 46/79 Comparator: 24/72 OR = 3.0 (95% CI [1.5, 6.0]) *Self-rated questionnaire - adherence to activities* Intervention = 32/71 Control = 17/54 OR = 1.8 (95% CI [0.8, 3.8])
Brosseau, 2012[18] **High ROB**	9 months	*Number of attended walking sessions/ number of prescribed sessions* Intervention mean = 0.445 (SD = 0.433) Comparator mean = 0.446 (SD = 0.441) Mean difference = NR, *p*-value = 0.989

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
Ben-Ami, 2017[19] **Serious ROB**	Estimated at 9 months	Baecke Physical Activity Questionnaire (BPAQ) Intervention mean = 0.8 (95% CI [0.4, 1.3]) Comparator mean = 0.1 (95% CI [-0.3, 0.6]) Mean difference = 0.7 (95% CI [0.07, 1.3])
Friedrich, 1998[27] Companion: Friedrich 2005[28] **High ROB**	3 months	*Treatment compliance after termination of the treatment program in weeks* Intervention mean = 10.6 (SD = 2.7) Comparator mean = 10.3 (SD = 2.9) Mean difference = NR
	11 months	*Treatment compliance after termination of the treatment program in weeks* Intervention mean = 28.8 (SD = 18.5) Comparator mean = 30.1 (SD = 20.5) Mean difference = NR
	5 years	*Years that rehabilitation program was performed regularly* Intervention mean = 3.5 (SD = 2.0) Comparator mean = 4.4 (SD = 2.2) Mean difference = NR
Lonsdale, 2017[24] **High ROB**	3 months	*Specific adherence to back rehabilitation at home (percentage of prescribed sessions completed per week)* Mean difference = 2.57 (95% CI [-6.05, 11.19]) *Home based adherence (self-reported overall adherence to their physiotherapists' recommendations using 7-point rating scales)* Mean difference = 0.35 (95% CI [-0.13, 0.83])
Sequential		
Bennell, 2014[23] **Low ROB**	6 months	*Self-reported adherence to home rehabilitation* Intervention mean = 6.1 (SD = 3.2) Comparator mean = 5.5 (SD = 3.5) Mean difference = 0.6, *p*-value > 0.05 *Home rehabilitation sessions completed* Intervention mean = 56% (SD = 34) Comparator mean = 51% (SD = 37) Mean difference = NR, *p*-value > 0.05

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
Bennell, 2020[20] **Low ROB**	6 months	*Exercise Adherence Rating Scale (EARS)* Intervention mean = 16.3 (SD = 6.6) Comparator mean = 13.4 (SD = 7.1) Mean difference = 3.1 (95% CI [0.8, 5.5]) *Number of days home rehabilitation completed in the past week* SMS Intervention mean = 1.9 (SD = 1.2) Comparator mean = 1.3 (SD = 1.2) Mean difference = 0.6 (95% CI [0.2, 1.0])
Quicke, 2017[22] **Some concerns about ROB**	3 months	*"Been doing exercises as often as advised" (n (%))* Targeted rehabilitation adherence arm: Strongly agree = 22 (17%); Agree = 72 (57%); Not sure = 14 (11%); Disagree = 17 (13%); Strongly disagree = 2 (2%) Usual care arm: Strongly agree = 15 (11%); Agree = 48 (36%); Not sure = 23 (17%); Disagree = 36 (27%); Strongly disagree = 11 (8%)
	12 months	*"Been doing exercises as often as advised" (n (%))* Targeted rehabilitation adherence arm: Strongly agree = 18 (15%); Agree = 42 (36%); Not sure = 22 (19%); Disagree = 25 (21%); Strongly disagree = 10 (9%) Usual care arm: Strongly agree = 12 (9%); Agree = 50 (37%); Not sure = 17 (13%); Disagree = 42 (31%); Strongly disagree = 13 (10%)
Baker, 2020[21] **High ROB**	24 months	*"How would you rate your level of adherence to the prescribed BOOST exercise program over the last 3 months?"* Intervention mean = 3.63 (95% CI [2.70, 4.56]) Control mean = 4.01 (95% CI [3.03, 4.99]) Mean difference = -0.38 (95% CI [-1.67, 0.91])

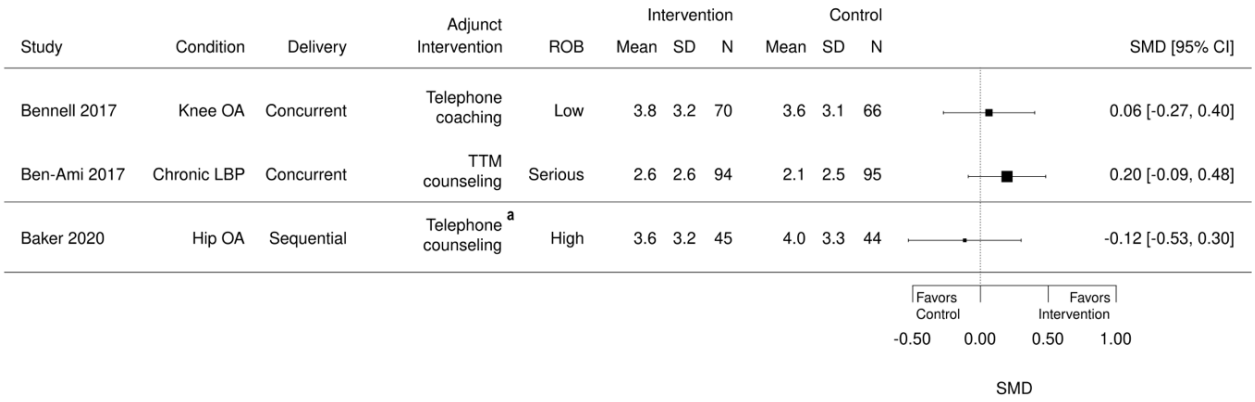
Abbreviations. NR=not reported; NRS=numeric rating scale; OR=odds ratio; ROB=risk of bias; SD=standard deviation.

Figure 6. Forest Plot of Adherence Outcomes at 3 to 6 Months



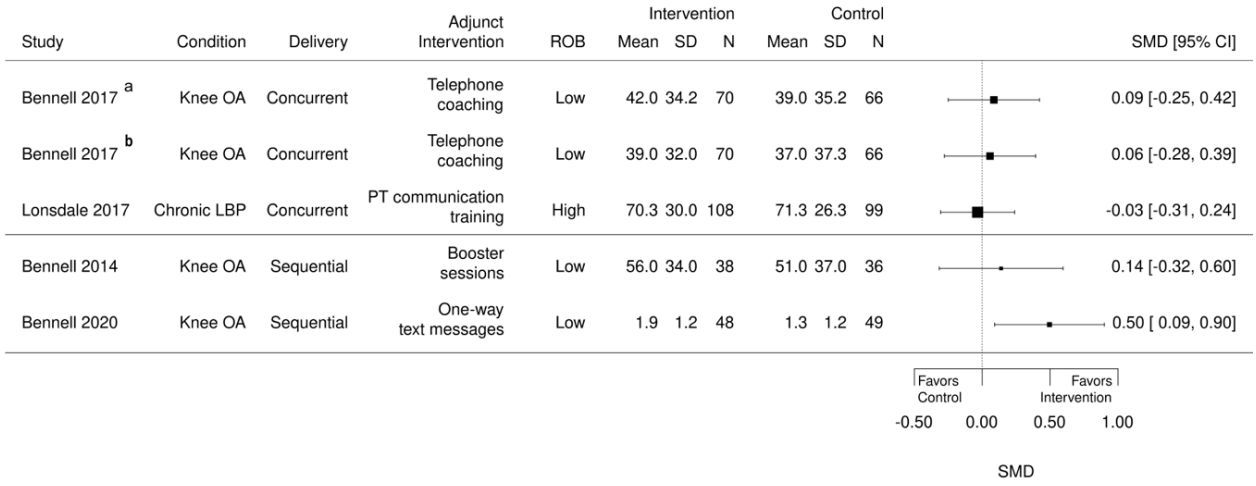
Notes. Bennell 2017 outcomes reported at 6 months after end of rehabilitation; Lonsdale 2017 outcomes reported at 3 months after end of rehabilitation; Bennell 2014 outcomes reported at 6 months after end of rehabilitation; Bennell 2020 outcomes reported at 6 months after end of rehabilitation.

Figure 7. Forest Plot of Adherence Outcomes at 9+ Months



Notes. Bennell 2017 outcomes reported at 12 months after end of rehabilitation; Ben-Ami 2017 outcomes reported at approximately 9 months after end of rehabilitation; Baker 2020 outcomes reported at 24 months after end of rehabilitation. [a] Computer-based telephone counseling.

Figure 8. Forest Plot of Adherence Outcomes as Percent of Prescribed Rehabiliation



Notes. Lonsdale 2017 outcomes reported at 3 months after end of rehabilitation; Bennell 2014 outcomes reported at 6 months after end of rehabilitation; Bennell 2020 outcomes reported at 6 months after end of rehabilitation. [a] Bennell 2017 outcomes reported at 6 months after end of rehabilitation. [b] Bennell 2017 outcomes reported at 12 months after end of rehabilitation.

Physical Function

All but 1[18] of the 10 included studies reported on function as an outcome to evaluate intervention impact. Across the studies, function was assessed by several established self-reported outcome measures including the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)—a well-validated, self-report measure for individuals with OA with a functional status subscale,[21-23,25] the Roland-Morris Disability Questionnaire for back pain,[19,24] the Knee and Osteoarthritis Outcome Score (KOOS) functional subscale,[20] and the low back outcome score.[27] Two studies reported both self-reported function and objective measures of function including several indicators of strength and flexibility in key lower extremity muscle groups.[21,27] As noted above for adherence outcomes, function was assessed at a range of time points spanning from 3 months to 5 years from the end of the index rehabilitation program. Functional status was considered the primary outcome or co-primary outcome in 4 studies.[19,22,23,25]

For functional outcomes, we considered the difference in change from end of index to follow-up between study arms. For *concurrently* delivered adherence adjunct interventions, function was typically reported as baseline (pre-index rehabilitation) to follow-up; thus, we calculated the mean difference in change from end of rehabilitation to follow-up from reported data when possible.

Concurrently Delivered Adjunct Adherence Interventions (N = 5)

Among the 5 concurrently delivered adherence adjunct interventions[19,24-27] that measured function as an outcome, 4 were rated to have high or serious ROB.[19,24,25,27] Pisters et al[26] was rated to have some concerns for ROB and reported functional status via the indirect assessment of meeting physical activity recommendations among participants with hip or knee OA who received usual physiotherapy with or without an adjunct intervention informed by operant conditioning and self-regulation principles. They reported a higher proportion of individuals in

the intervention arm achieved rehabilitation goals versus the comparator arm at both end of index rehabilitation (OR = 5.3, 95% CI [1.9, 14.8]) and 12 months after end of index rehabilitation (OR = 2.9, 95% CI [1.2, 6.7]). Of the 4 high/serious ROB studies, only 1 reported a positive intervention effect. Ben-Ami et al found a significant intervention benefit for difference in change of functional status as measured by the Roland-Morris Disability Questionnaire from pre-index rehabilitation program to 9 months post-index rehabilitation (change in mean difference = 2.7, 95% CI [0.9, 4.5]).[19] This falls below the estimated clinically meaningful difference of 3–5-point threshold.[29] Finally, 2 papers from Friedrich et al report on a single high ROB study that examined the addition of a motivational counseling intervention to a submaximal graded rehabilitation program and found better performance on the fingertip-to-floor distance test at 3 months after the end of intervention in the motivation adjunct group that was not sustained at 11 months.[27,28] See Table 4 for additional details. However, when considering mean change from end of index rehabilitation to follow-up as measured by SMD, there was no evidence of benefit among concurrently delivered adjunct interventions at 3–6 months (SMD range = -0.12– -0.02). At 9 months or longer, SMDs were generally larger, but were more inconsistent than at earlier timepoints and were nonsignificant (SMD range = -0.23–0.20) (Figures 9 and 10).

Sequentially Delivered Adjunct Adherence Interventions (N = 4)

Four studies delivered adjunct adherence interventions after the end of the index rehabilitation program and also measured functional outcomes.[20-23] By design, sequentially delivered trials evaluated effect as a mean difference from intervention baseline (*ie*, end of index rehabilitation) to follow-up time point. There was no evidence of significant treatment effect at 3 to 6 months (SMD range = -0.04–0.02) across 2 low ROB studies and one with some concerns (Figure 9). Similarly, there was no evidence of significant treatment effect at 9 months or longer (SMDs = -0.04 and 0.10) in 1 high ROB study and 1 study with some concerns for ROB (Figure 10). Of note, there was no evidence of intervention effect on function at 6 months for the 1 low ROB study by Bennell et al that demonstrated improved adherence among participants receiving 24 weeks of sequentially delivered behavior change text messages.[20]

Table 4. Physical Function Results

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
Concurrent		
Bennell, 2017[25] **Low ROB**	6 months	*Western Ontario and McMaster Universities Osteoarthritis Index (function subscale)* Intervention mean at end of rehabilitation = 52.6 (SD = 16.3) Comparator mean at the end of rehabilitation = 48.8 (SD = 16.4) Intervention mean = 13.3 (SD = 10.5) Comparator mean = 17.4 (SD = 11.9) Mean difference = 3.9 (95% CI [-0.3, 8.2])[a] SMD (change from end of treatment) = -0.05 (95% CI [0.39, 0.28])

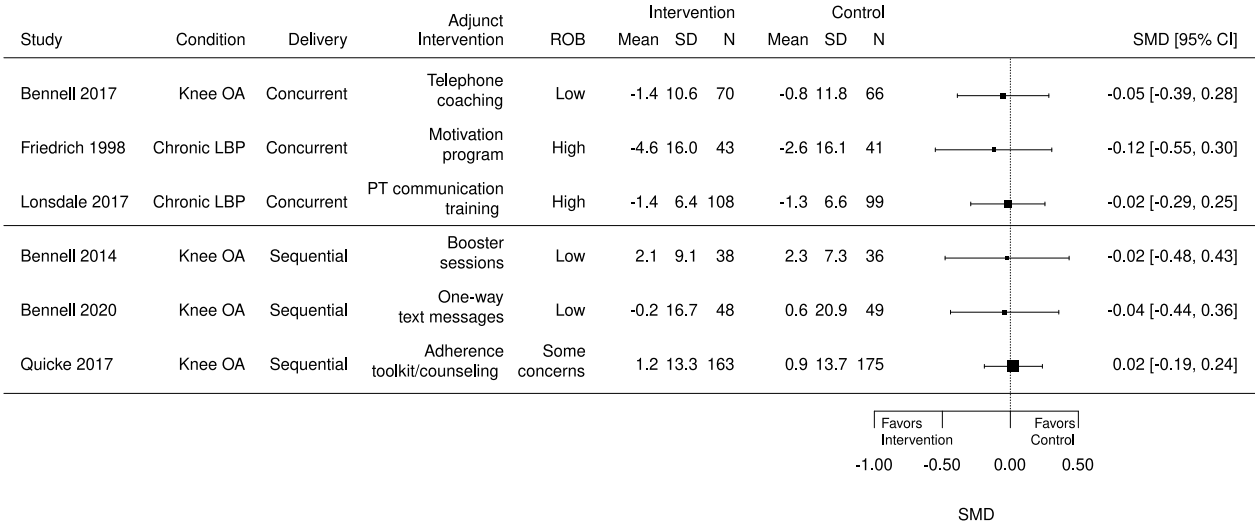
Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
	12 months	*Western Ontario and McMaster Universities Osteoarthritis Index (function subscale)* Intervention mean at end of rehabilitation = 52.6 (SD = 16.3) Comparator mean at the end of rehabilitation = 48.8 (SD = 16.4) Intervention mean = 12.2 (SD = 10.5) Comparator mean = 16.4 (SD = 11.7) Mean difference = 3.9 (95% CI [-1.0, 8.7])[a] SMD (change from end of treatment) = -0.06 (95% CI [-0.41, 0.28])
Pisters, 2010[26] **Some concerns about ROB**	13 months	*Meeting recommendations for physical activity* Intervention = 76/87 Comparator = 67/92 OR = 2.9 (95% CI [1.2 to 6.7])
Ben-Ami, 2017[19] **Serious ROB**	Estimated at 9 months	*Roland-Morris Disability Questionnaire* Intervention change in mean from baseline = 6.7 (95% CI [5.4, 8.0]) Comparator change in mean from baseline = 4.0 (95% CI [2.7 to 5.2]) Change in mean difference = 2.7 (95% CI [0.9, 4.5]) SMD (change from end of treatment) = 0.20 (95% CI [-0.09, 0.49])
Friedrich, 1998[27] Companion: Friedrich 2005[28] **High ROB**	3 months	*Low back outcome score* Intervention mean = 57.2 (SD = 15.7) Comparator mean = 51.0 (SD = 15.7) Mean difference = NR *Fingertip to floor distance* Intervention mean = 8.6 (SD = 18.6) Comparator mean = 16.6 (SD = 18.4) Mean difference = NR, *p*-value = 0.01 SMD (change from end of treatment) = -0.12 (95% CI [-0.55, 0.30])
	11 months	*Fingertip to floor distance* Intervention mean = 4.3 (SD = 6.1) Comparator mean = 10.1 (SD = 13.0) Mean difference = NR, *p*-value = 0.052 *Low back outcome score* Intervention mean = 58.9 (SD = 12.6) Comparator mean = 50.9 (SD = 18.7)

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
		Mean difference = NR SMD (change from end of treatment) = -0.23 (95% CI [-0.70, 0.24])
	5 years	*Disability* Intervention mean = NR Comparator mean = NR Mean difference = NR Intervention arm showed greater improvement in disability vs control between 12 months and 5 years (*p*-value = 0.003)
Lonsdale 2017[24] **High ROB**	3 months	*Roland-Morris Disability Questionnaire* Intervention mean = NR Comparator mean = NR Difference in change from baseline intervention vs Comparator = 0.09 (95% CI [-1.43, 1.6]) SMD (change from end of treatment) = -0.02 (95% CI [-0.29, 0.25])
Sequential		
Bennell, 2014[23] Sequential **Low ROB**	6 months	*Western Ontario McMaster Universities Osteoarthritis Index (function subscale)* Intervention mean = 20.2 (SD = 12.4) Comparator mean = 21 (SD = 12.3) Mean difference = -0.3 (95% CI [-0.4, 3.5])[b] SMD (change from end of treatment) = -0.02 (95% CI [-0.48, 0.43])
Bennell, 2020[20] Sequential **Low ROB**	6 months	*Function Knee Injury and Osteoarthritis Outcome Score (KOOS) function subscale* Intervention mean = 72.4 (SD = 17.6) Comparator mean = 70 (SD = 21.1) Mean difference = -0.2 (95% CI [-6.7, 6.3])[b] SMD (change from end of treatment) = -0.04 (95% CI [-0.44, 0.36])
Quicke, 2020[22] Sequential **Some concerns about ROB**	3 months	*Western Ontario McMaster Universities Osteoarthritis Index (function subscale)* Intervention mean = 22.7 (SD = 13.3) Comparator mean = 22.3 (SD = 13.3) Mean difference = -0.7 (95% CI [-3.3, 1.9])[a] SMD (change from end of treatment) = 0.02 (95% CI [-0.19, 0.24])
	12 months	*Western Ontario McMaster Universities Osteoarthritis Index (function subscale)*

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
		Intervention mean = 23 (SD = 14.4) Comparator mean = 21.5 (SD = 14.4) Mean difference = 0.4 (95% CI [-2.6, 3.3])[a] SMD (change from end of treatment): 0.10 (95% CI [-0.11, 0.31])
Baker, 2020[21] Sequential **High ROB**	24 months	*Western Ontario McMaster Universities Osteoarthritis Index function subscale* Intervention mean = 12.74 (95% CI [9.78, 15.69]) Comparator mean = 13.09 (95% CI [9.76, 16.43]) Mean difference = -0.46 (95% CI [-4.84, 3.93])[b] SMD (change from end of treatment) = -0.04 (95% CI [-0.46, 0.37]) *Quad strength* Intervention mean = 0.30 (95% CI [0.27, 0.34]) Comparator mean = 0.32 (95% CI [0.28, 0.35]) Mean difference = 0.02 (95% CI [-0.01, 0.05]) *Hamstring strength* Intervention mean = 0.15 (95% CI [0.13, 0.17]) Comparator mean = 0.16 (95% CI [0.14, 0.18]) Mean difference = 0.00 (95% CI [-0.02, 0.02]) *Timed up and go test (seconds)* Intervention mean = 7.45 (95% CI [6.91, 8.00]) Comparator mean = 7.71 (95% CI [6.71, 8.71]) Mean difference = -0.19 (95% CI [-1.13, 0.75]) *Repeated chair stands (5 times, seconds)* Intervention mean = 13.43 (95% CI [12.40, 14.45]) Comparator mean = 13.40 (95% CI [12.50, 14.31]) Mean difference = -0.12 (95% CI [-1.55, 1.31]) *Stair climb (seconds)* Intervention mean = 13.72 (95% CI [12.14, 15.30]) Comparator mean = 13.53 (95% CI [11.11, 15.94]) Mean difference = 0.31 (95% CI [-1.81, 2.43])

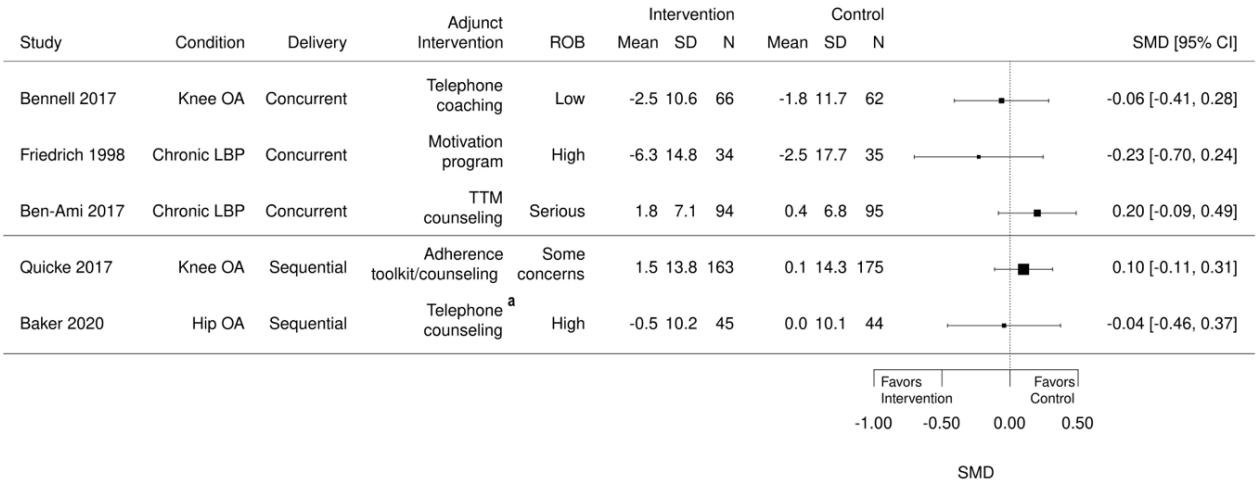
Notes. [a] Change from pre-rehabilitation baseline to follow-up. [b] Change from post-rehabilitation baseline to follow-up.
Abbreviations. NR=not reported; NRS=numeric rating scale; OR=odds ratio; ROB=risk of bias; SD=standard deviation; SMD=standardized mean difference.

Figure 9. Forest Plot of Physical Function Outcomes at 3 to 6 Months



Notes. Bennell 2017 outcomes reported at 6 months after end of rehabilitation; Friedrich 1998 outcomes reported at 3 months after end of rehabilitation; Lonsdale 2017 outcomes reported at 3 months after end of rehabilitation; Bennell 2014 outcomes reported at 6 months after end of rehabilitation; Bennell 2020 outcomes reported at 6 months after end of rehabilitation; Quicke 2017 outcomes reported at 3 months after end of rehabilitation.

Figure 10. Forest Plot of Physical Function Outcomes at 9 Months



Notes. Bennell 2017 outcomes reported at 12 months after end of rehabilitation; Friedrich 1998 outcomes reported at 11 months after end of rehabilitation; Ben-Ami 2017 outcomes reported approximately 9 months after end of rehabilitation; Quicke 2017 outcomes reported at 12 months after end of rehabilitation; Baker 2020 outcomes reported at 24 months after end of rehabilitation. [a] Computer-based telephone counseling.

Self-Efficacy

Five studies reported on self-efficacy for exercise or related constructs as an intermediate outcome of interest due to its role as an important determinant of long-term adherence. Two of the 4 studies measuring self-efficacy were delivered concurrently[18,24] and 2 were delivered sequentially.[20,22] One additional study with a concurrent intervention[27] reported on motivation, a distinct but related construct that, for the purpose of this review, is reported here. In all 5 studies, self-efficacy was reported as a secondary outcome (Table 5).

Concurrently Delivered Adjunct Adherence Interventions (N = 3)

All 3 concurrent studies reporting self-efficacy-related constructs had high ROB. The Lonsdale[24] study examined 2 subdomains: "autonomous motivation to follow recommendations" (subdomain of the Treatment Self-Regulation Questionnaire) and "controlled motivation to follow recommendations" (subdomain of the Treatment Self-Regulation Questionnaire) among patients with chronic LBP and found no significant intervention effect. The Friedrich[27] study reported motivation towards exercise therapy via selected questions from a Psychotherapy Motivation Questionnaire and found no significant difference.

The third concurrent[18] study examined the "confidence about doing things" and "coping with symptoms" subdomains of the Stanford Questionnaire on Chronic Disease among patients with knee OA and reported a significantly improved "confidence about doing things" at 6 months post-index rehabilitation in the intervention group (a behavioral adjunct intervention delivered concurrently to a supervised walking intervention) versus walking intervention alone ($p = 0.041$).

Sequentially Delivered Adjunct Adherence Interventions (N = 2)

Both sequential studies (1 with some concerns for ROB[22] and 1 low ROB[20]) utilized validated measures for self-efficacy: Self-Efficacy for Exercise Scale (SEE), which they used to measure a participant's "confidence in ability to exercise,"[22] and the Arthritis Self-Efficacy Scale (ASES), which breaks down self-efficacy as it relates to "pain," "function," and "other."[20] Bennell et al (2020) found no evidence of treatment effect on any of the subdomains at 24 weeks after index rehab program. Quicke et al[22] reported no statistically significant change within or between treatment arms.

Table 5. Self-efficacy Results

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
Concurrent		
Brosseau, 2012[18] **High ROB**	6 months	*Stanford questionnaire on chronic disease; coping with symptoms subdomain* Intervention mean = 1.388 (SD = 0.856) Comparator mean = 1.064 (SD = 0.952) *p*-value = 0.286
	6 months	*Stanford questionnaire on chronic disease; confidence about doing things subdomain* Intervention mean = 7.546 (SD = 1.848) Comparator mean = 7.690 (SD = 1.920) *p*-value = 0.041
Friedrich, 1998[27] Companion: Friedrich 2005[28] **High ROB**	Estimated at 9 months	*Attitude towards exercise therapy* Intervention mean = 6.3 (SD = 1.6) Comparator mean = 5.6 (SD = 2.1)

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
Lonsdale 2017[24] **High ROB**	3 months	*Autonomous motivation to follow recommendations* Mean difference = -0.10 (95% CI [-0.35, 0.16]), *p*-value = 0.41
	3 months	*Controlled motivation to follow recommendations* Mean difference = -0.15 (95% CI [-0.69, 0.38]), *p*-value = 0.57
Sequential		
Bennell, 2020[20] Sequential **Low ROB**	6 months	*Arthritis Self-Efficacy Scale (ASES)* *Self-efficacy: pain* Intervention mean = 6.6 (SD = 2.2) Comparator mean = 6.4 (SD = 2.1) Difference in change from baseline between groups = -0.4 (95% [CI -1.2, 0.4]) *Self-efficacy: function* Intervention mean = 8.3 (SD = 1.5) Comparator mean = 8.2 (SD = 1.7) Difference in change from baseline between groups = 0.1 (95% CI [-0.5, 0.7])
Quicke, 2020[22] Sequential **Some concerns about ROB**	3 months	*Self-Efficacy for Exercise (SEE)* Intervention mean = 5.7 (SD = 2.2) Comparator mean = 5.4 (SD = 2.3) Mean difference = 0.4 (95% CI [0.8, -0.2])

Abbreviations. ROB=risk of bias; SD=standard deviation.

Adverse Events

Four studies reported adverse events associated with interventions to improve long-term adherence to rehabilitation programs [20,22,23,25] Overall, there was no evidence of increased adverse events among patients receiving adjunct adherence interventions (Table 6).

Bennell et al (2014)[23] determined adverse events by questionnaire at the end of a 24-week adjunct intervention of 2 booster PT sessions after an index rehabilitation program. They reported few adverse events; specifically, 6 participants reported increased knee pain (4 intervention vs 2 control) and 1 participant from the control group reported increased hip pain.

A second study by Bennell et al (2017)[25] collected adverse event reports prospectively through log sheets collected every 3 months for an adjunct telephone coaching intervention delivered concurrently to an index rehabilitation program. They reported that adverse events occurred primarily during intervention delivery and were infrequent during the post-treatment follow-up period. During the treatment phase, 21 of 84 participants from the intervention arm reported 23 adverse events, compared with 21 of 84 participants in the comparator arm reporting 27 adverse events. The most common event was increased knee pain (17 or 26% intervention vs 16 or 23%

comparator). Other adverse events were reported less frequently, including pain in other regions, swelling/inflammation, and increased stiffness. Adverse events were less frequent during the follow-up period from the end of the index intervention to 12 months post-end of index, when 7 intervention participants reported 8 adverse events and 12 comparator participants reported 13 events. Similarly, increased knee pain was most frequent.

A third study by Bennell et al (2020)[20] considered adverse events to be "any problem participant believed was caused by advice received and required them to seek treatment or take medication and/or interfered with function for ≥ 2 days." They found no difference in overall adverse events between arms (16% sequentially delivered behavioral change text message intervention vs 15% usual care, $p = 0.53$), for knee pain (9% vs 6%, $p = 0.38$), or pain in other areas (7% vs 9%, $p = 0.48$).

Quicke et al[22] reported 2 adverse events in the arms of interest for this review; 1 participant in the comparator arm had a twisted ankle, and 1 in the sequential monitoring intervention arm had a fall while walking. Of note, the authors reported expected soreness and transient increases in pain among 12% of intervention participants and 19% of comparator participants.

Table 6. Adverse Events Results

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
Concurrent		
Bennell, 2017[25] **Low ROB**	12 months	*Number of adverse events during treatment phase* Total number: Intervention = 7 (11%) Comparator = 2 (19%) Increased knee pain: Intervention = 5 (8%) Comparator = 9 (15%) Pain in other region: Intervention = 2 (3%) Comparator = 4 (6%) Swelling/Inflammation: Intervention = 1 (2%) Comparator = 0 (0%)
Sequential		
Bennell, 2014[23] **Low ROB**	6 months	*Adverse events* Increased knee pain: Intervention = 4 Comparator = 2

Study Risk of Bias	Time After End of Rehabilitation Program	Outcome
		Increased hip pain: Intervention = 0 Comparator = 1
Bennell, 2020[20] Sequential **Low ROB**	6 months	*Any adverse event* Intervention = 9 (16%) Comparator = 8 (15%) *p*-value = 0.53 Knee pain: Intervention = 5 (9%) Comparator = 3 (6%) *p*-value = 0.38 Pain in other areas: Intervention = 4 (7%) Comparator = 5 (9%) *p*-value = 0.48
Quicke, 2020[22] Sequential **Some concerns about ROB**	12 months	*Adverse events* Sprained ankle: Intervention = 0 Comparator = 1 Fall while walking: Intervention = 1 Comparator = 0

Abbreviations. ROB=risk of bias.

Quality of Evidence

Risk of bias was assessed separately for each study design and outcome type (*ie,* patient reported and objectively measured) using the RoB 2 and the ROBINS-I tools. Overall, only 4 studies were judged to be low ROB. Key sources of bias across study designs and outcomes include deviations from intended intervention, bias in outcome assessment, and missing outcome data. Missing outcome data was a particular issue for studies reporting outcomes at later time points. Four studies were downgraded to high ROB on the missing outcome data domain.[18,21,24,27]

For the 7 individually randomized controlled trials, the ROB (Figure 11) for patient-reported outcomes was judged to be low for 3 studies, some concerns for 1 study, and high for 3 studies.[18,20-23,25,27] Patterns that led to judgments of high ROB and some concerns for ROB (Figure 12) included (1) some concerns about the randomization process; (2) deviations from intended interventions; (3) deviations from adherence to the intervention; (4) missing outcome data; (5) bias in measurements of the outcome; and (6) bias in selection of the reported result.

Of the 3 individually randomized controlled trials reporting objective outcomes, 1 was low risk and 2 were high risk.[18,21,27] Patterns that led to judgments of high ROB (Figure 13 and 14) included: (1) some concerns about the randomization process; (2) deviations from intended interventions; (3) some concerns about deviations from adherence to the intervention; (4) missing outcome data; (5) bias in measurements of the outcome; and (6) bias in selection of the reported result.

Of the 2 cluster-randomized controlled trials, 1 was judged to have some concerns and 1 was judged as high ROB.[24,26] Patterns that led to judgments of high ROB and some concerns for ROB (Figure 15 and 16) included: (1) missing outcome data; (2) bias in measurements of the outcome; and (3) some concerns for bias in selection of the reported result.

The 1 non-randomized study evaluated with the ROBINS-I tool was assessed to have serious risk of bias.[19] Patterns that led to judgments of high ROB and some concerns for ROB included: (1) bias due to confounding; (2) bias due to deviations from intended interventions; (3) moderate risk of bias due to measurement of outcomes; and (4) bias in selection of reported results (Figure 17).

Figure 11. Risk of Bias Ratings Across Randomized Trials: Patient-reported Outcomes

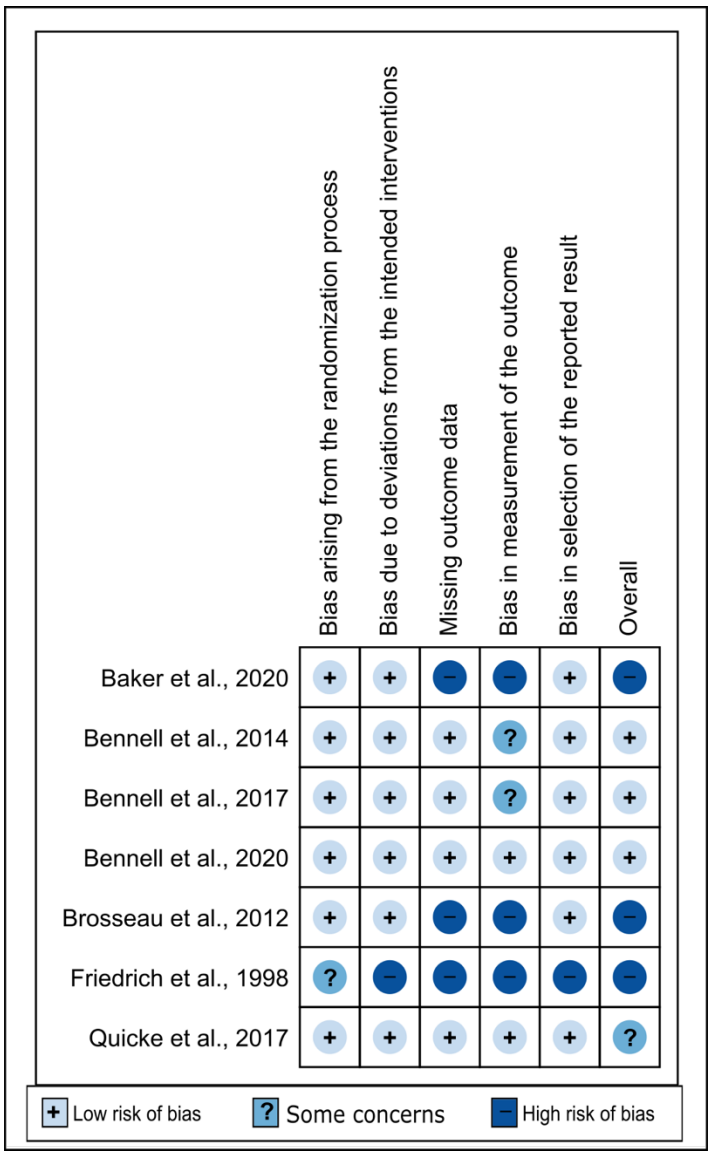


Figure 12. Risk of Bias Ratings by Bias Domain: Patient-reported Outcomes

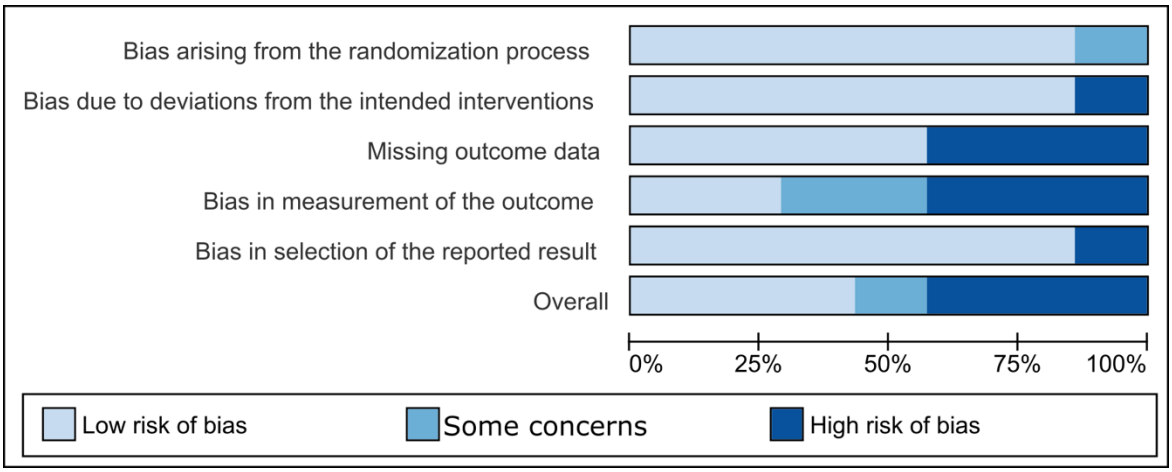


Figure 13. Risk of Bias Ratings Across Randomized Trials: Objective Outcomes

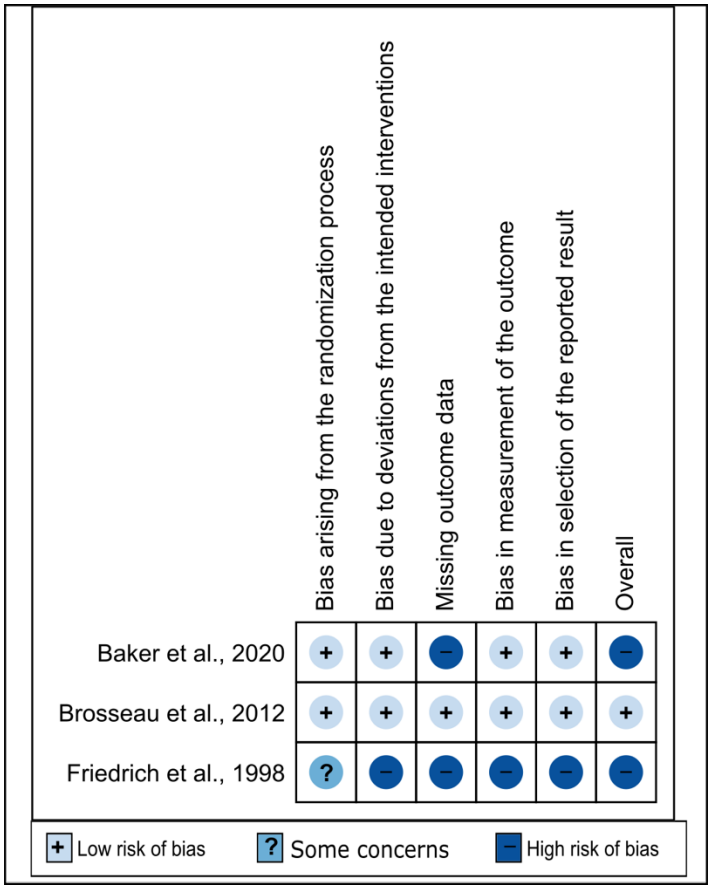


Figure 14. Risk of Bias Ratings by Bias Domain: Objective Outcomes

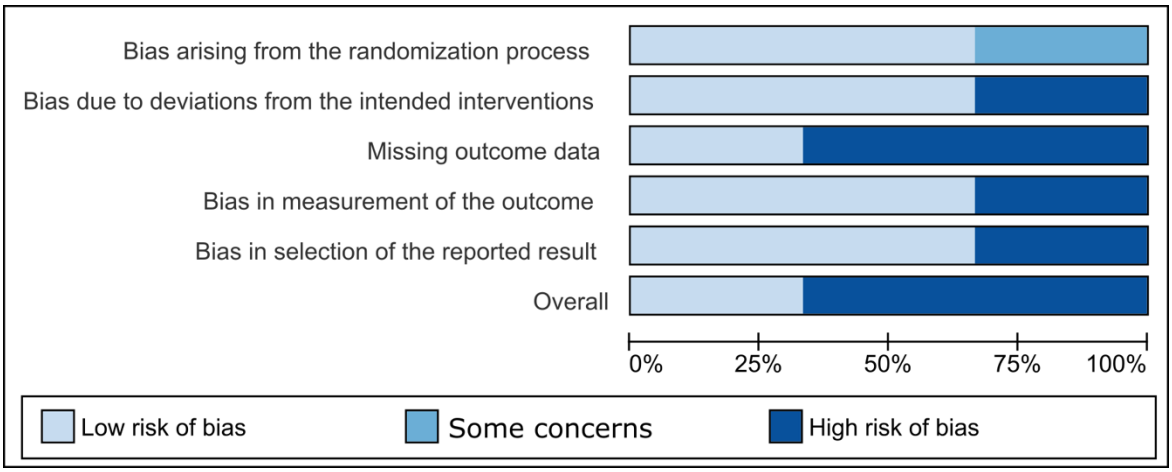


Figure 15. Risk of Bias Ratings for Cluster-randomized Trials

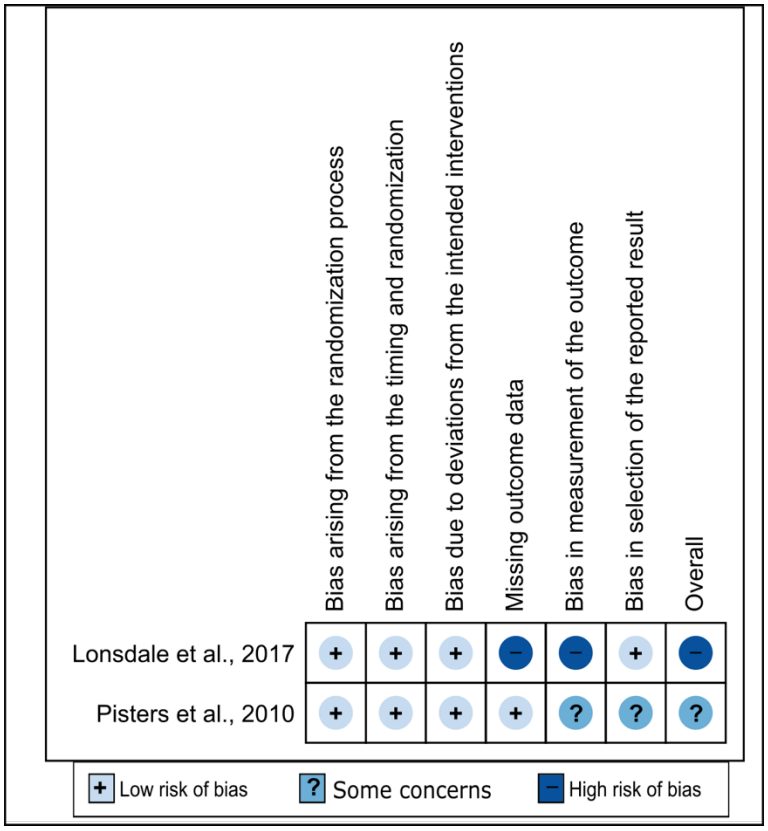


Figure 16. Risk of Bias Ratings by Bias Domain: Objective Outcomes (Cluster-randomized Trials)

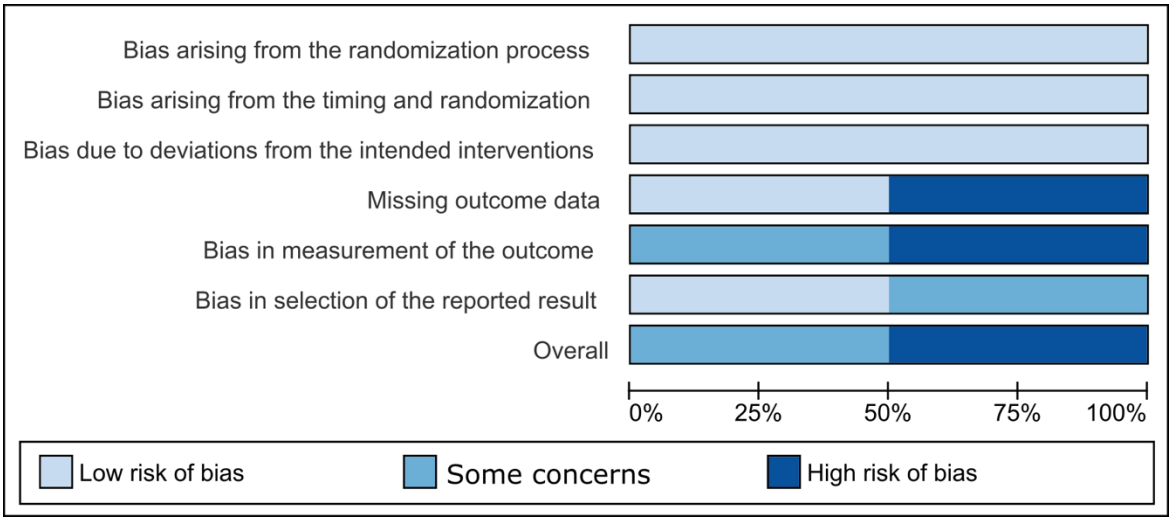
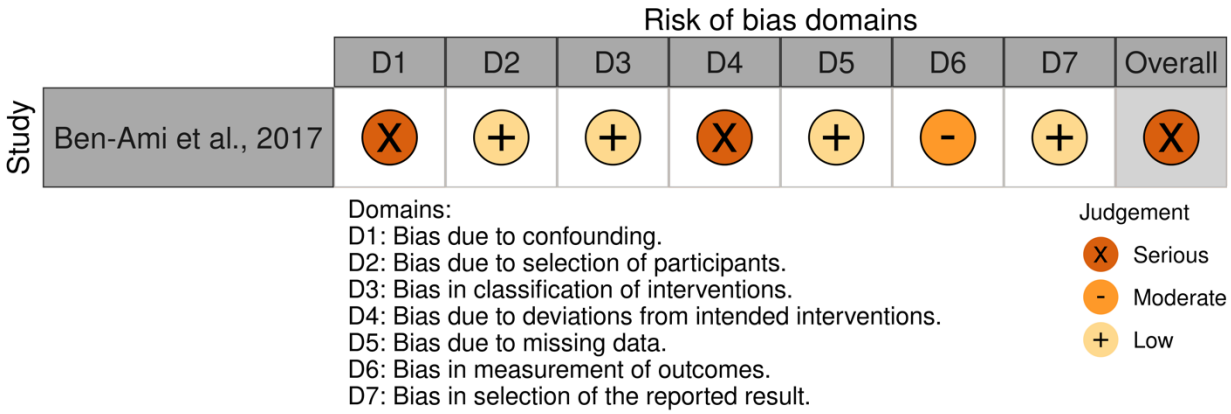


Figure 17. Risk of Bias Ratings for Non-randomized Trials



DISCUSSION

We evaluated the impact of physical rehabilitation programs supplemented with 1 or more adjunct components designed to promote long-term adherence to recommended rehabilitation programs. Specifically, we evaluated the effect of these interventions on self-efficacy for exercise, adherence to recommended home rehabilitation program, and function at ≥ 3 months after completing the index rehabilitation program among adults with hip/knee OA or LBP. Our review is novel; we focus on sustained adherence to physical rehabilitation programs supplemented with adherence-enhancing adjunct components, and we conducted a rigorous analysis of the adjunct components using an established tool, the Behavior Change Technique Taxonomy (v1).[10]

SUMMARY OF FINDINGS

We identified 10 studies that included physical rehabilitation programs supplemented by adherence-enhancing adjunct interventions. Six studies were theory informed and included elements of the Transtheoretical Model,[30] Self-Determination Theory,[31] COM-B (capability, opportunity, and motivation),[32] Social Cognitive Theory,[33] and/or Health Change methodology.[34] None explicitly included Veterans or focused on a predominantly Veteran population. We identified behavior change techniques present in adherence-enhancing adjunct interventions and in control interventions. We found limited evidence of benefit across the included interventions on long-term adherence and no evidence for benefit to functional outcomes, though few of the evaluated adherence interventions were theory based or addressed long-term home rehabilitation program adherence as distinct from initiation. Self-efficacy and adverse events were sparsely reported.

The majority of included studies (60%) delivered the adjunct adherence-enhancing intervention concurrently with the index rehabilitation program. Yet, delivering these approaches at the same time may not be an optimal strategy to foster sustained adherence to PT over time. Moreover, some health behavior models suggest that initiation of PT and long-term adherence to PT are conceptually different behaviors that require different skills and psychological processes for support.[35,36] If long-term behavioral maintenance of a home rehabilitation program is the appropriate clinical goal for patients with chronic musculoskeletal conditions, then the conceptual difference between starting and sustaining physical rehabilitation is critical. Designing interventions that disentangle behavioral initiation and maintenance (*ie*, sequential interventions) and target distinct content to support these behaviors may lead to improved results.[7,37-41]

We coded BCTs in adjunct adherence-enhancing interventions and comparator interventions. Comparator interventions generally used BCTs in similar amounts and clusters across studies, which is reflective of typical practice in rehabilitation settings during the initiation of a new home rehabilitation program. Most adjunct adherence-enhancing interventions included few individual BCTs (mean = 5.5), while only 3 included more than 8 BCTs, which prior literature has suggested can enhance behavioral maintenance.[5] Further, many BCT clusters remain largely unexplored. Because behavior change is a complex phenomenon, the lack of complexity in the adjunct interventions as seen by the few BCT clusters explored remains a missed opportunity. Moreover, the majority of interventions from studies in our review included BCTs from clusters already represented in the comparator arm (such as goal setting, feedback and monitoring, and

repetition and substitution). While none addressed a rationale for this overlap, only 1 study specifically refers to the BCTs as a part of intervention development. Because initiating a behavior and behavioral maintenance are distinct psychological processes requiring different skills, goals, and processes of change, designing interventions that focus on "just more of the same" BCTs may be insufficient to promote behavioral maintenance. Studies that were theory informed and embraced the distinction between initiation of behaviors and behavioral maintenance (such as Bennell et al[20] and Ben-Ami et al[19]) tended to include more BCTs in the adjunct adherence-enhancing interventions and demonstrated BCTs across a broader range of clusters compared to studies that did not address this distinction.

Adherence was generally reported using non-validated self-report measures. Three studies had evidence of a positive effect on our primary outcome of long-term adherence to recommended home rehabilitation programs across end points within included studies. Of these 3 positive studies, 1 was a low-ROB study by Bennell et al[20] The second study with serious ROB reported a mean difference of 0.7 (95% CI [0.07, 1.3]) on the validated Baecke Physical Activity Questionnaire at 9 months from the end of an enhanced intervention informed by the Transtheoretical Model for patients with LBP. When considering the difference at follow-up between intervention and comparator arms, only the study by Bennell et al[20] had a beneficial effect for both measures of long-term adherence, specifically general self-reported adherence and adherence as a proportion of the prescribed home rehabilitation program completed, with an SMD of 0.42 (95% CI [0.02, 0.82]) and an SMD of 0.50 (95% CI [0.09, 0.90]), respectively.

All but 1 included study[18] measured functional outcomes and all used at least 1 established self-report measure of function. Two studies also included objective measures of function including several indicators of strength and flexibility in key lower extremity muscle groups.[21,27] Three studies with concurrently delivered adherence adjunct interventions reported a positive effect of the intervention on functional status from pre-index rehabilitation to follow-up, but all had some concerns for ROB or were high ROB. To evaluate sustained functional improvement, we considered the difference in change of function from the end of rehabilitation to follow-up. There was no evidence of intervention effect at any time point, including across both concurrently and sequentially delivered interventions and across the 3 low-ROB studies.

We attempted to identify measures of self-efficacy to carry out home practice of prescribed rehabilitation exercise, but given the limited assessments of this construct, we included related constructs (*eg*, self-efficacy for managing arthritis, motivation to follow [rehabilitation] recommendations, and confidence in doing things [in the context of knee OA]). Of the 5 studies reporting these constructs, only 2 used validated measures specifically related to self-efficacy of any type. One low-ROB study by Bennell et al[20] used the Arthritis Self-Efficacy Scale and found no difference between the sequentially delivered semi-interactive SMS message adjunct intervention and comparator at 24 weeks across any of the 3 subscales (*ie*, pain, function, controlling other symptoms). Of the other 4 studies, only 1 high-ROB study[18] found a significant difference using a non-validated measure assessing confidence-like attitudes. However, we note that self-efficacy is most accurately measured when related to a specific behavior, so these related findings are tangentially relevant. In addition, it is unclear if any of the studies measuring self-efficacy included intervention strategies to specifically target this construct. While we assessed the BCTS of the included interventions, it is unknown which BCTs are most effective at promoting self-efficacy.[42,43] Four studies reported adverse events, though none found any

difference in events by receipt of adjunct adherence interventions and most of those reported were minor musculoskeletal discomforts.

Certainty of Evidence for Key Outcomes

To contextualize the overall base of the evidence on key outcomes, we conducted Certainty of Evidence (COE) ratings for adherence and function outcomes. These assessments reflect the degree of confidence we have in our summary findings. For each outcome of interest, we present the COE by outcome (*ie,* adherence, function) and time point (*ie,* 3 to 6 months, ≥ 9 months). The non-randomized study and studies reporting categorical outcomes are evaluated separately (Table 7).

We identified low COE that adjunct adherence interventions have no effect on adherence to rehabilitation at 3 to 6 months and 9 months after the end of the rehabilitation period. Adjunct components had no significant effect when studies reported adherence as percent adherent to the prescribed dose of rehabilitation. These were also determined to be very low certainty. We found low certainty and very low certainty that adherence interventions have no effect on physical function at 3 to 9 months and very low certainty at 9 months. Ratings of low and very low COE indicate that the true effect of adjunct interventions on long-term adherence to recommended rehabilitation programs and physical function might be considerably different from the estimated effect we found in the included studies. Future studies may shift these COE ratings.

Table 7. Certainty of Evidence for Rehabilitation Adherence by Intervention and Outcome Timing

Intervention	Number of Studies (N)	Findings	Certainty of Evidence (Rationale)
Adherence 3 to 6 months	4 randomized (514 participants)	SMD range = 0.05–0.42 (95% CI range = -0.23–0.82)	**Very low certainty of no effect** (rated down for serious risk of bias, serious inconsistency, and serious imprecision)
	1 randomized (200 participants)	OR = 2.9 (95% CI [1.2, 6.7])	**Very low certainty of increased adherence** (rated down for serious risk of bias, serious indirectness, and serious imprecision)
Adherence 9+ months	2 randomized (225 participants)	SMD range = -0.12–0.06 (95% CI range = -0.53–0.40)	**Very low certainty of no effect** (rated down for serious risk of bias, serious inconsistency, and serious imprecision)
	1 non-randomized (189 participants)	SMD = 0.20 (95% CI [-0.09, 0.48])	**Very low certainty of no effect** (rated down for serious risk of bias and serious imprecision)
	1 randomized (200 participants)	Adherence to rehabilitation: OR = 3.0 (95% CI [1.5, 6.0]) Adherence to activities: OR = 1.8 (95% CI [0.8, 3.8])	**Very low certainty of increased adherence** (rated down for serious risk of bias, serious indirectness, and serious imprecision)

Intervention	Number of Studies (N)	Findings	Certainty of Evidence (Rationale)
Adherence % of Dose Prescribed	4 randomized (514 participants)	SMD range = -0.03–0.50 (95% CI range = -0.31–0.90)	**Very low certainty of no effect** (rated down for serious risk of bias, serious inconsistency, serious imprecision)
Physical Function 3 to 6 months	6 randomized (936 participants)	SMD range = -0.12–0.02 (95% CI range = -0.55–0.24)	**Low certainty of no effect** (rated down for serious risk of bias and serious imprecision)
	1 randomized (200 participants)	OR = 5.3 (95% CI [1.9, 14.8])	**Very low certainty of increased function** (rated down for serious risk of bias, serious indirectness, and serious imprecision)
Physical Function 9+ months	4 randomized (624 participants)	SMD range = -0.23–0.10 (95% CI range = -0.70–0.31)	**Low certainty of no effect** (rated down for serious risk of bias and serious imprecision)
	1 non-randomized (189 participants)	Mean = 0.20 (95% CI [-0.09, 0.49])	**Very low certainty of no effect** (rated down for serious risk of bias, and serious imprecision)
	1 randomized (200 participants)	OR = 2.9 (95% CI [1.2, 6.7])	**Very low certainty of increased function** (rated down for serious risk of bias, serious indirectness, and serious imprecision)

Notes. Randomized and non-randomized designs were not combined as per GRADE guidance.[17] Studies reporting dichotomous outcomes were not be combined with studies reporting continuous outcomes.
Abbreviations. OR=odds ratio; SMD=standardized mean difference.

PRIOR SYSTEMATIC REVIEWS

Several prior systematic reviews provide additional context for our findings. Nicolson et al[44] aimed to determine the effectiveness of interventions to increase adherence to therapeutic exercise among older adults with LBP and/or hip/knee OA. Four studies in this review reported improved adherence from 4 weeks to 12 months (SMD= 0.26–1.23) and standardized mean differences with low to very low COE indicated a small effect in favor of adjunct sessions. Yet, the authors of this review defined adherence in a way that included short-term (< 3 months) adherence or adherence during delivery of a rehabilitation intervention. In contrast, our review focused on adherence following an index rehabilitation intervention and was interested in long-term adherence (≥ 3 months) after completing the index rehabilitation intervention, and few interventions demonstrated improvements in this outcome. Moreover, we allowed the inclusion of high-quality non-randomized trials in our review that were excluded by Nicolson et al. Four[18,23,26,27] of our included studies overlapped with Nicolson et al, likely due to similar populations, outcomes, and inclusion criteria.[18,23,26,27] However, our results extend the work of Nicolson et al in providing data on long-term adherence to home rehabilitation programs.

Two prior reviews examined the use of BCTs to improve adherence to exercise or physical activity. Eisele et al[45] examined the effectiveness of BCTs to enhance physical activity among patients with chronic musculoskeletal conditions across 22 studies (3 included in our review[18,19,25]). A subgroup analysis examining the difference between high BCT (defined as an

adherence-enhancing intervention containing ≥ 8 BCTs) and low BCT (defined as an adherence-enhancing intervention containing < 8 BCTs) interventions found a higher effect (SMD = 0.29, 95% CI [0.19, 0.40]) for interventions using a greater number of BCTs. Our results largely follow this trend with the exception of Pisters et al[26] (adherence-enhancing intervention containing 2 BCTs and a positive effect) and Friedrich et al[27] (adherence-enhancing intervention containing 10 BCTs and a null result). Comparing our review to Eisele et al reveals that while researchers and clinicians often focus primarily on intervention content, our results point to the importance of considering the comparator arm content in comparison to the intervention. Specifically, we found that adjunct adherence interventions largely employed similar BCTs to those used in comparator arms. To move the field forward, interventions designed to improve long-term adherence to home rehabilitation programs should make sure that intervention BCTs build on and complement those BCTs used in the routine rehabilitation programs that focus on initiating a home rehabilitation program; in particular, interventions should employ BCTs with the theoretical grounding and an evidence base that supports the maintenance of behavior change.

Including 24 studies (2 included in our review),[23,25] a systematic review by Willett et al[46] identified 5 BCTs that had high effectiveness ratios (≥ 50%) in promoting adherence to exercise among those with hip/knee OA (behavioral contract, nonspecific reward, goal setting [behavior], self-monitoring of behavior, and social support [unspecified]). Two of the 5 effective BCTs identified by Willett et al were present in nearly all (80%, self-monitoring of behavior) or all (goal setting [behavior]) interventions included in our review. In contrast, 3 of the 5 effective BCTs were rarely seen (behavioral contract, 20%; nonspecific reward, 30%; social support [unspecified], 30%) in our review. Including these BCTs known to be effective at promoting exercise adherence may enhance the effectiveness of future interventions designed to enhance adherence, especially as the intention to perform exercises and social support are previously identified predictors of long-term adherence to exercise.[5]

Jordan et al[11] completed a Cochrane review of 42 RCTs (1 included in our review[27]) examining interventions including self-management interventions, psychological interventions, and rehabilitation interventions to improve exercise adherence for individuals with chronic musculoskeletal pain. The authors' conclusions were limited by a lack of high-quality RCTs with long-term follow-up that explicitly address adherence to exercises and the lack of standard validated measures of exercise adherence. Though these recommendations are now 12 years old, based on our review findings we believe that these conclusions remain valid.

CLINICAL AND POLICY IMPLICATIONS

As noted, we found little evidence for the benefit of existing adjunct adherence interventions on long-term adherence or functional outcomes. Included studies differed in many core features, including patient population, follow-up length, and study quality, as well as in how they approached the goal of engaging patients with chronic musculoskeletal conditions in the long-term practice of prescribed home rehabilitation programs. The adjunct adherence interventions we identified included a limited number of established strategies (*ie*, BCTs) known to promote sustained behavior change, used the same strategies as are used for initial rehabilitation treatment, and generally did not draw a distinction between initiation and maintenance of home rehabilitation programs.

These findings and methodological limitations make specific clinical recommendations challenging. Nonetheless, we believe a few key concepts may inform current clinical practice. First, rehabilitation clinicians and primary care providers should consider disentangling support for starting a rehabilitation program and coaching to commit to long-term rehabilitation recommendations. In doing so, rehabilitation clinicians should approach the prescription of home rehabilitation as a behavior change initiation conversation and employ appropriate approaches for initiating a new behavior.

Second, typical rehabilitation practice utilizes a number of strategies (*ie*, BCTs) as part of the standard of care for LBP and lower limb arthritis[47] (*eg*, goal setting, behavioral practice, and information about health consequences). When shifting aims to the promotion and encouragement of long-term sustainment of a home rehabilitation practice after successful initiation, clinicians need to employ a targeted and distinct set of strategies for maintenance.[5,7] Unfortunately, the field lacks evidence-based or clinical guidelines to draw from to inform which strategies, or BCTs, are most appropriate for the promotion of the sustained practice of prescribed home rehabilitation programs in the context of LBP or hip/knee OA. We can draw from other fields of behavioral maintenance that suggest approaches such as a shift in self-regulatory focus[48,49] (*ie*, focus on approaching a favorable endpoint vs avoiding a less favorable alternative state), relapse prevention planning, fostering effective self-monitoring, and shifting social support from the physical therapist to the patient's social network.[50] We can also look to existing successful VHA programs that seek to promote long-term behavior change. While not rehabilitation specific, the VA has already invested in some programs to promote the long-term physical function of Veterans, using social support. Two such examples include the nationally disseminated VHA Gerofit program, with demonstrated evidence of improvement in morbidity and mortality[51] (now being disseminated nationwide), and the Peer-To-Peer Whole Health program.[52]

LIMITATIONS

It is important to consider our findings within the context of both the limitations of our methodological approach to this systematic review and those of the identified literature meeting our inclusion criteria.

Our methodological approach includes multiple strengths, including following an *a priori* developed protocol, obtaining guidance for approach and eligibility criteria from an expert panel, using a conceptual model to frame our review, and rigorous categorization of behavioral change techniques reported in the included interventions using an established method. It should be noted that we focused this review on common chronic musculoskeletal conditions that require long-term maintenance for improvement of function; findings may not be relevant to other clinical conditions requiring physical therapy for rehabilitation (*eg*, post joint replacement, after an acute injury). In addition, there may be other studies that did not explicitly intend to promote long-term adherence or measure adherence at time points 3 months and greater but that could provide useful insight into this topic. Further, half of the included studies did not have an *a priori* focus on long-term adherence and, as such, were not directly designed to address the key question proposed here about maintenance of physical rehabilitation programs. Our use of the BCT taxonomy also has limitations. Although 2 authors independently coded and reviewed the BCTs present in each study, reporting of control arm and intervention arm components was often insufficient. Thus, we cannot guarantee the completeness and comparability of the coded BCTs.

Finally, we did not attempt to combine studies reporting continuous and dichotomous outcomes; a future synthesis employing methods to do so may arrive at different conclusions."

Publication Bias

In the context of this review, which found a small number of included studies, existing statistical methods are not useful to detect publication bias. It is possible that there are existing studies or projects evaluating interventions to promote long-term adherence to physical therapy that were not published in the indexed literature. For example, it is possible that individual clinics or health care systems have developed internal programs to promote long-term rehabilitation adherence that have been evaluated as quality improvement projects but not published in the peer-reviewed literature.

Study Quality

We were also limited by the quality of identified studies. Common potential sources of bias across the included studies included an inadequate description of intervention delivery, deviations from intended intervention delivery, missing outcome data (especially for longer-term outcome assessment time points), and reliance on self-reported outcomes with the potential for bias.

Heterogeneity

Potential sources of heterogeneity in effects include the participating patient population, the length of follow-up assessments (which ranged from 3 months to 60 months), measurement of key outcomes (*eg*, type of instrument used), and the type of interventions themselves. Specifically, 6 of the included studies[18,19,24,25,27,28,53] reported on adjunct adherence interventions delivered concurrently to the index rehabilitation intervention and 2 focused on training the PT providers in advance of providing direct patient care. On the other hand, 4 studies evaluated the effect of interventions delivered after the completion of index rehabilitation care, effectively extending the contact and support provided to participants. While we categorized studies as delivering the adjunct intervention either concurrently to the index rehab program or sequentially, the identified studies were not always easy to classify. In some cases, this was due to overlap of the adherence adjunct intervention both during the index rehab program and subsequently (*eg*, Pisters et al[26] and Quicke et al[22]). In addition, we sought to include studies whose sole comparison was the addition of an adjunct adherence intervention to a standard rehabilitation program (*ie*, A vs A + B study design). However, in an effort to identify potentially relevant literature, some of the included studies did not feature an index rehabilitation intervention identical to that of the comparator (*eg*, Quicke et al[22]). This was particularly challenging to clarify in studies that administered the adjunct adherence intervention concurrently with the index rehabilitation program.

Applicability of Findings to the VA Population

While none of the included studies were conducted in the VA or specifically sought to include Veterans, the identified studies were conducted in settings *similar* to the VA Health Care System, and it is reasonable to expect they would function similarly. In addition, the participants in the included studies are similar in age and comorbidities to Veterans cared for in the VA.

FUTURE RESEARCH

To guide our assessment of important gaps in the existing literature, we consider each category in the PICOTS (population, intervention, comparator, outcomes, timing, setting) framework (Table 8). We identify those study design characteristics that we feel would provide the greatest contribution to this body of literature given the current state of the evidence. For each of the gaps described in Table 8, we identified that there is currently insufficient information.

Table 8. Highest Priority Evidence Gaps for Long-term PT Adherence

PICOTS Domain	Evidence Gap/Area for Future Exploration
Population	• Populations including underrepresented racial and ethnic groups • Younger patients with knee and hip osteoarthritis and lower back pain, as their challenges and needs for incorporating long-term strategies into working-age lifestyles may be different from other age groups
Intervention	• Distinction between interventions promoting the initiation of behavior change versus behavioral maintenance grounded in best theoretical/conceptual approaches • Adherence-enhancing adjunct interventions that use different BCTs than are typically seen in usual rehabilitation care • Interventions aimed at both the rehabilitation provider and patient simultaneously • Virtual and/or asynchronous interventions for flexibility and convenience of long-term patient engagement • Titrating adherence interventions to individual's needed level of support • Use of BCTs known to be effective from related literature for long-term home adherence • Clearly described and varied dose of the intervention delivered to patients
Comparator	• Well-described usual care/standard rehabilitation programs that clearly demonstrate provision of standards of care and identified behavior change techniques • Various delivery modalities in order to compare in-person to virtually delivered
Outcomes	• Objective functional outcomes *(eg*, 6-minute walk test, 30-second sit to stand test) • Validated measures specific to self-efficacy for exercise/physical activity • Standardized and validated measures of adherence (objective when possible, such as accelerometer data)
Timing	• Longer-term outcomes at least 6 months after completion of index rehabilitation program to facilitate comparison across studies
Setting	• Community-based rehabilitation

Future Intervention Design Considerations

Initiation of behavior change requires a skill set fundamentally different from that needed to maintain behavior change.[7] Long-term adherence to home rehabilitation programs prescribed by rehabilitation clinicians should be considered behavioral maintenance and thus requires different BCTs, goals, and skills compared to behavioral initiation. Moreover, the potential for the type,

sequence, and number of BCTs to interact dynamically to optimally promote behavioral initiation and maintenance offers new avenues for intervention development.

While we are unable to draw definitive conclusions about the type of interventions most likely to lead to long-term adherence and functional improvement, we can suggest the types of strategies that could be explored in the future, including social support, behavioral contracts, and the use of rewards. Social support is particularly intriguing for VA-based rehabilitation adherence efforts, as social support delivered through peer support has been shown to be broadly accepted and effective within the Veteran population,[54-56] and peer support specialists are already incorporated into multiple kinds of VA care provision.[57,58] Further, theoretical and empirical evidence suggests the critical role of positive, structural social support from within the patient's own social network as a key factor in behavioral maintenance.[7,59,60]

The collected literature shows that the field of behavioral maintenance of home rehabilitation programs is nascent. In addition to methodologically rigorous randomized trials testing adjunct interventions designed to promote behavioral maintenance of prescribed home rehabilitation, more recent innovations in clinical trials design such as SMART or MOST designs could be helpful to move this body of literature forward.[61] Programs should ensure that the adherence adjunct intervention arm is delivered in addition to an index rehabilitation program identical to that administered to the comparator arm (*ie*, a true A vs A + B comparison). This is particularly important for concurrently delivered adjunct interventions, from which adjunct components are inherently more difficult to disentangle compared to sequentially delivered adjunct intervention studies. Further, studies should consider a purposefully sequenced combination of intervention approaches (*ie*, behavior initiation followed by behavioral maintenance).

CONCLUSIONS

Long-term sustainment of functional improvements gained by short-term rehabilitation programs requires ongoing adherence to recommended home rehabilitation programs well past the end of direct clinical treatment. We found that there is inadequate evidence evaluating rigorously designed adherence-enhancing interventions for the specific promotion of long-term adherence to home rehabilitation programs. As long-term adherence represents a distinct behavioral target (*ie*, behavioral maintenance), future studies may want to consider testing interventions specifically built to target behavioral maintenance of home rehabilitation programs. Future development of interventions to promote long-term or sustained adherence to prescribed home rehabilitation programs could benefit from use of theoretically informed approaches and successful behavioral maintenance interventions validated in similar conditions. In the meantime, rehabilitation clinicians and referring providers should be aware that long-term commitment to prescribed home rehabilitation programs is necessary to realize ongoing health benefits.

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