National Institute for Health and Care Excellence

Final

Joint replacement (primary): hip, knee and shoulder

[C] Evidence review for preoperative rehabilitation

NICE guideline

Intervention evidence review underpinning recommendation 1.2.1 and the research recommendation in the NICE guideline

June 2020

Final

This evidence review was developed by the National Guideline Centre, hosted by the Royal College of Physicians

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1 Preoperative rehabilitation

1.1 Review question: Is preoperative rehabilitation clinically and cost effective for people having primary elective joint replacement?

1.2 Introduction

For many people who undergo hip, knee or shoulder replacement, recovery is difficult, prolonged and often painful. Symptoms generally improve with time, but some patients never regain optimal function of their joints. People planning to undergo joint replacement could participate in preoperative rehabilitation programmes as one possible way to optimise post-operative recovery, but there are no recommended national standards for such programmes.

Most current NHS preoperative programmes, when delivered, start between two to six weeks before the planned joint replacement operation and can be one-off appointments. For individuals awaiting hip and knee replacement, they are most frequently delivered in a group setting along with others waiting for joint replacement surgery. Programmes can be delivered by a variety of healthcare professionals either alone or in combination and can include: the provision of information on the expected pathways; advice on strategies to improve recovery e.g. nutritional advice, advice on sex before and after joint replacement, reducing smoking, alcohol consumption, improving diet and other lifestyle choices; advice and provision of exercises in preparation for surgery; advice on techniques for managing activities of daily living; and the provision and practice in using adaptive equipment such as raised toilet seats, dressing aids and walking aids e.g. crutches. Similar group programmes for shoulder replacements are less common due to fewer operations being performed.

Currently there is national variation in preoperative rehabilitation provision in the UK, in terms of whether this is routinely offered, what the content of the programme is and whether this is delivered in a group setting or via a 1-to1 approach.

This review seeks to discover the clinical and cost effectiveness of preoperative rehabilitation before hip, knee or shoulder replacement and identify whether individualised programmes with specific aims delivered by a rehabilitation team are more effective than usual care.

1.3 PICO table

For full details, see the review protocol in Appendix A: dichotomous

Table 1: PICO characteristics of review question

Population	Adults awaiting primary elective hip, knee or shoulder joint replacement surgery
Intervention	Individualised preoperative rehabilitation programmes from the time surgery is offered, involving multiple sessions, prescribed and supervised exercises and advice by a member of the rehabilitation team
Comparison	No formal preoperative rehabilitation or usual care class without an individualised program
Outcomes	**Critical** • Quality of life within 6 to 24 months (continuous): for example EQ-5D, EQ-VAS • Patient Reported Outcome Measures (PROMs) within 6 to 24 months (continuous) • Revision of joint replacement (time to event)

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	• Depression within 2 years (dichotomous) • Disability (continuous) within 6 to 24 months **Important** • Hospital readmissions: within 90 days (dichotomous) • Muscle atrophy within 2 years (dichotomous) • Length of stay (continuous) **To be extracted when not included within a PROM:** • Function / ADL / return to work within 6 to 24 months (continuous/ dichotomous) • Pain within 2 years (continuous)
Study design	Randomised controlled trials If no well-conducted RCTs are available then observational studies with multivariate analysis will be investigated.

1.4 Clinical evidence

1.4.1 Included studies

A search was conducted for randomised trials comparing the effectiveness of individualised preoperative rehabilitation programmes versus no program or usual care for patients awaiting primary elective hip, knee or shoulder joint replacement surgery.

Eight randomised controlled trials were included in the review;[5, 6, 23, 30, 33, 38, 45, 85] these are summarised in Table 2 below. Evidence from these studies is summarised in the clinical evidence summary below (Table 3).

The aims of the studies included assessment of whether undertaking an individualised preoperative rehabilitation programmes improved preoperative experience, reduced length of stay in hospital, increased the speed of recovery of function after surgery and led to improved function and quality of life.

See also the study selection flow chart in Appendix C: study evidence tables in Appendix D: forest plots in Appendix E: and GRADE tables in Appendix H:

1.4.2 Excluded studies

See the excluded studies list in Appendix I:

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1.4.3 Summary of clinical studies included in the evidence review

Table 2: Summary of studies included in the evidence review

Study	Intervention and comparison	Population	Outcomes	Comments
Beaupre 2004[5]	**Intervention:** Advice and equipment: crutch walking, bed mobility and transfers, postoperative ROM routine. Exercise: designed to improve knee mobility and strength. 12 sessions over 4 weeks. **Comparison:** Continued regular activities until surgery.	People with non-inflammatory arthritis and on a waiting list for primary total knee replacement. N=131	• Quality of life: SF36 MCS • Quality of life: SF36 PCS • PROMs: WOMAC function • PROMs: WOMAC pain • PROMs: WOMAC stiffness • Length of stay	Canada
Berge 2004[6]	**Intervention:** Pain management Programme (PMP): Advice: educating people on arthritis, hip function and general health issues. Exercise and equipment: behaviour change in terms of exercise, joint protection and pacing activity. Utilising cognitive methods to address fears and frustrations alongside relaxation techniques. 6-week period prior to surgery. **Comparison:** Usual care involving toning exercises and joint replacement written advice and advice on postoperative period.	People on a waiting list for hip replacement for at least 6 months N=40.	• Function (AIMS score) • Pain	UK Exercise component emphasised throughout intervention program.
Crowe 2003[23]	**Intervention:**	People scheduled for total	• Length of stay	Canada

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Study	Intervention and comparison	Population	Outcomes	Comments
	Rehabilitation team undertake an assessment and formulate program based on needs. Advice: video, booklet, information on length of stay, discharge criteria, respite care and diet. Exercise: physical conditioning program available that focused on improving strength and endurance. All subjects received extensive individualized counselling from an occupational therapist. Beginning between 1 to 24 weeks prior to surgery **Comparison:** Usual care of one appointment involving education on surgery and postoperative period.	hip or knee joint replacement N=133 Subjects were included who were not functioning well because of their joint dysfunction, and who also had limited social support, and/or comorbid medical conditions. Subjects were excluded if they were functioning well despite their joint dysfunction, and were managing their activities of daily living well with good carer support.		Considered indirect because it is unclear how many participants undertook the physical conditioning program
Doiron-Cadrin 2019[30]	**2 Intervention groups:** 12 week program with 2 supervised physiotherapy sessions each week. 1 group was supervised in-person and the other by telecommunication. People were required to complete an exercise log book. Tailored prescription of exercises while monitoring pain, function and tolerance. Program contains proprioceptive exercises, cardiovascular warm up, education regarding medication usage, and ice application. **Comparison:**	Adults with severe OA who are on the waiting list for total knee arthroplasty or total hip arthroplasty N=34	No relevant outcomes were found. All outcomes were prior to surgery.	Canada

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Study	Intervention and comparison	Population	Outcomes	Comments
	Usual care involving a single home visit from a community-based physiotherapist and the person is given an information booklet on surgery, medication, and rehabilitation.			
Ferrara 2008[33]	**Intervention:** Exercise: group and individual exercises for five days per week with some physical therapist contact. Advice and equipment: movements that should be avoided, preventing dislocation of prostheses, the use of devices, correct posture, lifting and carrying, washing and bathing. Program begins one month prior to surgery. **Comparison:** Usual care	People with end-stage osteoarthritis on a waiting list for total hip replacement N=23	• Pain	Italy
Gocen 2004[38]	**Intervention:** Exercise: instructed to perform routine three times daily and evaluated by a physiotherapist. Advice and equipment: education on movements that should be avoided, use of devices, posture, lifting and carrying, washing and bathing. **Comparison:** No preoperative exercise or education program was given	People scheduled for total hip replacement (THR) with thrust plate prosthesis (TPP) and cementless acetabular component N=60	• PROMs: change in Harris Hip Score	Turkey
Huang 2012[45]	**Intervention:** In addition to usual care. Advice and equipment:	People with advanced osteoarthritis who are scheduled for unilateral	• Length of stay	Taiwan

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Study	Intervention and comparison	Population	Outcomes	Comments
	education program including hospitalization, discharge, post-TKA rehabilitation, safe transferring technique, guide for crutches and canes, and fall prevention. Exercise: thigh muscle strength training. Beginning 2 to 4 weeks prior to surgery. **Comparison:** Usual care where leisure activities and exercises were not prohibited.	primary total knee replacement N=243		
Vukomanovic 2008[85]	**Intervention:** Advice in 1 class: information about the operation, caution measures and rehabilitation after the arthroplasty through conversation with the physiatrist and a brochure. Exercise and equipment (2 classes): physiotherapist instructed exercises and basic activities from the postoperative rehabilitation program, such as bed mobility, getting out and in bed, standing and walking with crutches, use of toilet, sitting on chair, walking up and down stairs with aids. **Comparison:** Group did not receive intervention advice or exercise therapy classes	People with primary and secondary osteoarthritis who were scheduled for primary total hip replacement N=45	• PROMs: Oxford Hip Score • Length of stay	Serbia

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See Appendix D: for full evidence tables.

1.4.4 Quality assessment of clinical studies included in the evidence review

Table 3: Clinical evidence summary: individualised preoperative rehabilitation programmes versus usual care

Outcomes	No of Participants (studies) Follow up	Quality of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects	
				Risk with Control	Risk difference with Individualised preoperative rehabilitation (95% CI)
Quality of life: SF36 PCS Scale from: 0 to 100.	109 (1 study) 1 years	LOW[1,2] due to risk of bias, imprecision		The mean quality of life: SF36 PCS in the control groups was 58	The mean quality of life: SF36 PCS in the intervention groups was 2 lower (5.06 to 1.06 lower)
Quality of life: SF36 MCS Scale from: 0 to 100.	109 (1 study) 1 years	LOW[1,2] due to risk of bias, imprecision		The mean quality of life: SF36 MCS in the control groups was 41	The mean quality of life: SF36 MCS in the intervention groups was 3 lower (6.38 lower to 0.38 higher)
PROMs: change in Harris Hip Score Scale from: 0 to 100.	59 (1 study) 2 years	VERY LOW[1,2] due to risk of bias, imprecision		The mean proms: change in Harris Hip Score in the control groups was 50.96	The mean proms: change in Harris Hip Score in the intervention groups was 3.57 higher (4.52 lower to 11.66 higher)
PROMs: WOMAC function Scale from: 0 to 100.	109 (1 study) 1 years	MODERATE[1] due to risk of bias		The mean proms: WOMAC function in the control groups was 77	The mean proms: WOMAC function in the intervention groups was 0 higher (5.63 lower to 5.63 higher)
PROMs: WOMAC pain Scale from: 0 to 100.	109 (1 study) 1 years	LOW[1,2] due to risk of bias, imprecision		The mean proms: WOMAC pain in the control groups was 80	The mean proms: WOMAC pain in the intervention groups was 2 higher (3.45 lower to 7.45 higher)
PROMs: WOMAC stiffness Scale from: 0 to 100.	109 (1 study) 1 years	LOW[1,2] due to risk of bias, imprecision		The mean proms: WOMAC stiffness in the control groups was 71	The mean proms: WOMAC stiffness in the intervention groups was 4 lower (11.32 lower to 3.32 higher)

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Outcomes	No of Participants (studies) Follow up	Quality of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects	
				Risk with Control	Risk difference with Individualised preoperative rehabilitation (95% CI)
PROMs: Oxford Hip Score Scale from: 0 to 48.	36 (1 study) 15 months	VERY LOW[1,2] due to risk of bias, imprecision		The mean proms: Oxford Hip Score in the control groups was 17.59	The mean proms: Oxford Hip Score in the intervention groups was 0.53 lower (5.12 lower to 4.06 higher)
Revision of joint replacement	Not reported				
Depression	Not reported				
Disability	Not reported				
Length of stay	531 (4 studies)	VERY LOW[1,2,3] due to risk of bias, inconsistency, imprecision		The mean length of stay in the control groups was 8.9 days	The mean length of stay in the intervention groups was 1.22 days lower (2.42 to 0.01 lower)
Function (AIMS score) Scale from: 0 to 90.	33 (1 study) 8 months	VERY LOW[1,2] due to risk of bias, imprecision		The mean function (AIMS score) in the control groups was 49.12	The mean function (AIMS score) in the intervention groups was 6.23 lower (12.01 to 0.45 lower)
Pain (Change in VAS or NRS) Scale from: 0 to 10.	56 (2 studies) 3 or 8 months	VERY LOW[1,2] due to risk of bias, imprecision		The mean change in pain (NRS) in the control groups was -6.27	The mean pain (NRS) in the intervention groups was 0.63 lower (1.84 lower to 0.58 higher)

[1] Downgraded by 1 increment if the majority of the evidence was at high risk of bias and downgraded by 2 increments if the majority of the evidence was at very high risk of bias.
[2] Downgraded by 1 increment if the confidence interval crossed 1 MID or by 2 increments if the confidence interval crossed both MIDs.
[3] Downgraded by 1 or 2 increments because the point estimate varies widely across studies, unexplained by subgroup analysis. Random effects (DerSimonian and Laird) model was employed.

See Appendix F: for full GRADE tables.

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1.5 Economic evidence

1.5.1 Included studies

One health economic study was identified with the relevant comparison and it has been included in this review.[5] It is summarised in the health economic evidence profile below (Table 5) and the health economic evidence table in Appendix H:

1.5.2 Excluded studies

One health economic study that was relevant to this question was excluded due to an assessment of very serious limitations – see Appendix I:

See also the health economic study selection flow chart in Appendix G:

1.5.3 Unit costs

The weighted average of the HRG codes for primary elective hip, knee and shoulder replacements in Table 4 are based upon the average length of stay and average cost of an excess bed day.

Table 4: Weighted average unit cost for hip, knee and shoulder HRG codes

Intervention/ Diagnosis	Reference cost HRG	Weighted national average	Weighted average length of stay	Weighted average cost of excess bed day
Very Major Hip Procedures for Non-Trauma	Weighted for complications and co morbidities for HRG codes: HN12A, HN12B HN12C, HN12D, HN12E and HN12F; as recorded for Elective Inpatients	£6,571	3.93	£406.63
Very Major Knee Procedures for Non-Trauma	Weighted for complications and co morbidities for HRG codes: HN22A, HN22B HN22C HN22D and HN22E; as recorded for Elective Inpatients	£6,336	3.94	£406.95
Very Major Shoulder Procedures for Non-Trauma	Weighted for complications and co morbidities for HRG codes: HN52A, HN52B and HN52C; as recorded for Elective Inpatients	£6,240	2.17	£455.68

(a) Source: NHS Reference Costs 2017/18[27]

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1.5.4 Summary of studies included in the economic evidence review

Table 5: Health economic evidence profile: Preoperative rehabilitation versus no preoperative rehabilitation

Study	Applicability	Limitations	Other comments	Incremental cost	Incremental effects	Cost effectiveness	Uncertainty
Beaupre 2004[5] (Canada)	Partially applicable[(a)]	Potentially serious limitations[(b)]	People on a waiting list for total knee replacement. Advice and equipment: crutch walking, bed mobility and transfers, postoperative range of motion routine. Exercise: designed to improve knee mobility and strength. 12 sessions over 4 weeks. Randomised controlled trial Time horizon=12 months	+£1.63	Change in SF36 PCS: -3 MCS:+5	Indeterminate	No sensitivity analysis

Abbreviations: MCS=Mental component score (0-100); PCS=Physical component score (0-100); SF-36=Short-form 36
(a) No quality-adjusted life-years and Canadian setting
(b) Single underpowered trial. Costs from 1997/8. Baseline length of hospital stay is longer than in England. Discount rate was not reported

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1.6 Evidence statements

1.6.1 Clinical evidence statements

Evidence from 8 studies reported on people who are scheduled for hip or knee replacement surgery. No evidence was found for people scheduled for shoulder replacement surgery. The evidence review found no clinically important difference between individualised preoperative rehabilitation programs and usual care through 2 quality of life outcomes, 5 PROMs outcomes and 2 pain outcomes (moderate to very low quality, range of n=36-109). Evidence indicated a clinically important benefit for individualised preoperative rehabilitation programmes in terms of length of stay (4 studies, very low quality, n=531) and function (1 study, very low quality, n=33). No evidence was available for revision of joint replacement, depression or disability.

1.6.2 Health economic evidence statements

One cost-consequence analysis found that preoperative rehabilitation was only marginally more costly compared to usual care for patients waiting for total knee replacement with an indeterminate effect on quality of life. This analysis was assessed as partially applicable with potentially serious limitations.

1.7 The committee's discussion of the evidence

1.7.1 Interpreting the evidence

1.7.1.1 The outcomes that matter most

The critical outcomes were agreed to be quality of life (QOL), Patient Reported Outcome Measures (PROMs), time until joint replacements were revised, depression, and disability. PROMs measure health gain in patients undergoing joint replacement. PROMs vary in terms of content and can cover a range of clinical measures such as QOL, pain, stiffness, and function. Disability gives an indication of a person's function, and consequently their ability to return to work or undertake leisure activities. Returning to work and leisure activities can be important in terms of a person's QOL.

Important outcomes were hospital readmissions, muscle atrophy, and length of stay. It was agreed to utilise function or pain outcomes if they were reported separately and not included in a PROM extracted from the same study.

The follow-up timescales for QOL, PROMs, disability and function were 6 to 24 months. The committee agreed the meaningful longer-term effects of preoperative rehabilitation could be expected 6 months after surgery until 2 years after surgery. Adverse outcomes such as depression, muscle atrophy and pain could be measured up to 2 years after surgery. The hospital readmissions timescale was elected to be within 90 days to pick up varying serious clinical outcomes that can occur, for example surgical site infections, dislocations, thromboembolic disorders, postoperative pain and cardiac dysrhythmia.

30-day mortality after joint arthroplasty is a rare event usually due to pre-existing cardiovascular and/or pulmonary disease and the committee did not consider this to be altered by the usage of prescribed and supervised exercises and advice by a member of the rehabilitation team.

No evidence was found for the following critical outcomes: revision of joint replacement, depression, or disability.

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1.7.1.2 The quality of the evidence

There were 11 outcomes analysed from the studies, evidence quality tended to be graded as low or very low though in 1 case it was determined to be moderate. All outcomes were downgraded in quality due to risk of bias and in many cases due to imprecision. The most common reasons for increased risk of bias were lack of blinding of participants or outcome assessors and unclear methods of allocation concealment. The data from 1 study was considered indirect because it was unclear how many participants undertook the physical conditioning programme and thus the exercise aspect of the programme might have had limited coverage

1.7.1.3 Benefits and harms

The purpose of this clinical question was to consider a 'bigger package' than usual care. Usual care in hip or knee replacement consists of 1 to 2 group sessions with exercises and information about the surgery in terms of what to expect from the surgery, what is expected of them at the hospital and the postoperative process after the surgery. These are standardised rather than individualised programmes and should be provided to all people undergoing hip or knee joint replacement surgery at the very least. The committee conceptualised a bigger package of preoperative rehabilitation for hip and knee joint replacement surgery as an individualised programme with information on the surgery and the process in hospital with expectations of the outcome including possible adverse events, exercise interventions, assessment of ADL performance with advice and interventions to maximise ongoing independence, and health psychological assessment. This could include counselling, cognitive therapy, weight control, pain medication review, and optimised medication usage, all being given several weeks before the date of surgery. It was stated that information around sex after surgery can be of great importance to people and can play a key role in maintaining wellbeing. A committee member indicated that some of these aspects could plainly benefit people undergoing shoulder replacement surgery who currently receive no pre-operative input. The committee believe these interventions would be important for general health, cardiovascular health and maintenance of function and would be effective preparation for the joint replacement surgery. The educational and health psychology to enable a patient to be ready for discharge combined with exercise therapy and ADL advice / intervention to increase the speed of functional recovery. Preoperative rehabilitation could make people better able to deal with the possible complications after joint replacement surgery, promote understanding and engagement with postoperative rehabilitation, and prepare the person better for existing with a replaced joint. The outpatient aspects of these benefits would not be based on a reduction in length of stay and therefore could therefore apply to shoulder replacement surgery as well as hip and knee replacement surgery.

Eight randomised controlled trials were included in this evidence review. The people in the studies either had hip or knee replacement surgery. There were no studies including people who had shoulder replacement surgery. The preoperative rehabilitation interventions themselves contained aspects of the committee's understanding of what it should be but none had the combined duration, intensity and breadth of that specified as ideal by the committee. The committee concluded that this limited the abilities of the studies to show the true benefits of preoperative rehabilitation though benefits were seen in terms of function and length of stay.

The results of the evidence review saw no clinically important difference in terms of quality of life or in terms of 5 PROMs outcomes, and pain. In all cases, only 1 study reported on each outcome. A clinically important benefit for individualised preoperative rehabilitation programmes was seen in terms of length of stay, which was reported in 4 studies and function, which was reported in a single study.

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The committee agreed that the RCTs included in the evidence review were small and underpowered to show a clinically important benefit in terms of preoperative rehabilitation. In addition, the evidence informing the outcomes tended to be graded low or very low quality and this reduced trust in the evidence being an accurate representation of the interventions.

The length of stay data was consistent in all studies showing a reduction in the preoperative rehabilitation intervention group. However, 3 studies showed a small and consistent reduction whereas 1 study showed a much greater reduction. It was unclear why there was such variation in effect size, though the committee noted that this could have been influenced by the background healthcare setting. The meta-analysis of length of stay indicated a reduction of 1.22 days per person. However the committee noted that the mean length of stay in studies included in the review control arms were much higher than the current length of stay in NHS care. The review shows a mean of 8.9 days in the control arms, whereas the current NHS length of stay is 4.5 days for total knee arthroplasty, based on the current evidence available and the committee's clinical expertise. The committee considered the NHS length of stay is lower than the studies due to the effectiveness of usual care and the improvements that have happened in surgery and perioperative care. Therefore the committee agreed that a1.22 day reduction in length of stay in the NHS setting was unlikely to be fully realised but even reduced estimations could still be clinically and cost effective for NHS care. A lay member on the committee stated that wellbeing is improved by earlier discharge home and that these reductions would be of value to people who have had joint replacement surgery. The committee agreed that a mean reduction of 1 third of a day would still be a clinically important benefit. In terms of shoulder replacement, a committee member commented that shoulder replacement length of stay tends to be 1 night and shoulder replacement surgery in the USA is regularly undertaken as a day case. This very short length of stay and possible movement to a day case model means people having shoulder replacement surgery have a different length of stay model compared to people having hip and knee joint replacement. The committee agreed that length of stay is less of a driver for this intervention for shoulder joint replacement surgery.

The committee commented on the lack of consistency of the preoperative rehabilitation interventions in the RCTs included in the review. All included at least some form of exercise and advice and the sessions were individualised and as stated in the protocol with more than 1 rehabilitation session. There was inter-study variation in the exercise and information offered in terms of content and number of sessions and studies often included additional sessions, for example relaxation techniques or cognitive therapy within the preoperative rehabilitation. Thus it was difficult to exactly define what preoperative rehabilitation was in terms of the included randomised controlled trials outside of the definitive prescribed and supervised exercises and advice by a member of the rehabilitation team. Taken as a whole, the preoperative rehabilitation programmes found in the evidence-covered all the aspects stated by the committee. However no single study contained a preoperative rehabilitation programme that covered them all.

The interventions started at varying times before surgery, in 1 case it ranged from 1 to 24 weeks prior to surgery though multiple studies started 1 month prior to surgery. The committee agreed that exercise therapy is best undertaken at least 6 week prior to surgery and that this tended not to happen in the included studies and it was noted that this may have led to reduced positive effects of the intervention.

The committee also agreed through the evidence and consensus to offer preoperative rehabilitation advice to people having primary hip or knee replacement surgery but could not make a recommendation for people having shoulder replacement surgery. The committee stated a minimum set of areas that should be covered such as exercise advice, lifestyle advice, and advice about maximising functional independence and quality of life before and after surgery. This would include mobility independence. In addition the committee stated that wellbeing is a broad concept that includes personal dignity (including treatment of the individual with respect) physical and mental health and emotional wellbeing. They concluded

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preoperative rehabilitation could make people better able to deal with the possible complications after surgery, promote understanding and engagement with postoperative rehabilitation, and prepare the person better for existing with a replaced joint. The committee did not feel the evidence was strong enough to recommend an individualised programme and the advice offered was more similar to those in detailed in the RCTs included rather than the fuller programme detailed in the research recommendation. The committee discussed the type of exercises to prescribe. They agreed that these should be tailored to the person's needs and circumstances, taking into account their activities of daily living. No timing aspect was stated in the recommendation as the committee were conscious that while lengthier rehabilitation could be more effective, it could delay surgery and that might be in conflict with the wishes of people undergoing the surgery due to the continued pain, impaired function, and reduced quality of life.

The committee spoke about their understanding of similarities and differences inherent between shoulder replacement surgery and hip or knee replacement surgery. The similarities can be seen in terms of the benefits of giving structured individualised information on the surgery itself, and the possible postoperative experiences in the immediate and long term. Also there are benefits to having good cardiovascular exercise prior to surgery in the post-surgery period. However the committee did not feel there was a great deal of benefit attempting to learn post-surgery exercise routines prior to surgery as the exercises are unlikely to be possible before surgery. For similar reasons it is not possible to build up important muscle groups in the affected arm prior to surgery. Finally the number of people having shoulder replacement surgery is much lower than those having hip or knee surgery and the committee were unsure provision of preoperative rehabilitation would be cost saving or cost neutral in this group. Based on the lack of evidence of clinical benefit and uncertainty around the cost of preoperative rehabilitation the committee decided not to make a recommendation in people having shoulder replacement surgery.

The committee commented that there is a lack of research in this field and made a research recommendation to investigate a fuller, earlier programme of preoperative rehabilitation before hip, knee or shoulder replacement surgery with the usual care as comparator. This research should indicate whether or not there are additional benefits in the preoperative period to be found on top of current care when a full preoperative rehabilitation programme is employed.

1.7.2 Cost effectiveness and resource use

A single published economic evaluation was included. It found that preoperative rehabilitation was only marginally more costly compared with no preoperative rehabilitation for people waiting for primary total knee replacement. No evidence was found for hip and shoulder population.

This study was a randomised controlled trial included in the above clinical review. The length of stay reduction was typical of studies in that review, although the baseline mean length of stay was substantially higher than is typical in the UK today. The intervention was particularly intensive and the cost savings were partly attributable to reduction in readmissions, which was not studied in the other trials. The study also had limited applicability, since it was conducted in a Canadian setting, nearly twenty years ago and it was underpowered to detect an improvement in quality of life.

The committee expressed concerns about recommending a full preoperative rehabilitation programme (including a personalised, comprehensive and intensive intervention) due to the large resource impact and limitations of the evidence. However, the committee felt that the clinical and economic evidence was sufficient to make a strong recommendation in favour of advice on preoperative rehabilitation for people waiting for hip, and knee replacement. As the recommendation only concerns advice on preoperative rehabilitation, rather than a full programme, the recommendation will not have a large resource impact.

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The recommendation was made for hip and knee surgery but not for shoulder replacement due to the differences between shoulder replacement surgery and hip or knee replacement surgery. Unlike for hip and knee replacement, it is difficult to learn post-operative exercise routines prior to shoulder surgery as the exercises are unlikely to be possible before surgery. For similar reasons it is not possible to build up important muscle groups in the affected arm prior to shoulder surgery.

In current practice, preoperative rehabilitation is often provided in the form of a joint school for hip and knee replacements, which would be a one-off appointment providing education and exercises. There may however, be some resource impact for those areas where there is no joint school or pre-operative class in the form of additional staff time or venue location in order to give out the advice. This additional cost might be offset through a reduction in length of stay through patient adherence to preoperative rehabilitation advice.

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Appendices

Appendix A: Review protocols

Table 6: Review protocol: preoperative rehabilitation

ID	Field	Content
0.	PROSPERO registration number	Not registered
1.	Review title	Preoperative rehabilitation in shoulder joint replacement surgery
2.	Review question	Is preoperative rehabilitation clinically and cost effective for people having primary elective joint replacement?
3.	Objective	Recovery for a significant proportion of patients remains difficult and prolonged, and many never gain optimal functionality postoperatively. Preoperative rehabilitation programmes have been proposed as a potential way to expedite recovery times and improve overall extent of recovery in patients planning to undergo joint replacement. These can include physiotherapy, occupational therapy, nutritional counselling, acupuncture, transcutaneous electrical nerve stimulation, hydrotherapy or education interventions (pre-operative teaching programs) that might aid in recovery. There is currently variation in terms of the content and individuality of preoperative rehabilitation. In some cases, it is not routinely offered and in cases where it is offered it is not individualised for the person awaiting surgery. This review seeks to find out whether individualised programs with specific aims through the rehabilitation team are more effective than no program or non-individualised programs.
4.	Searches	The following databases will be searched: Cochrane Central Register of Controlled Trials (CENTRAL) Cochrane Database of Systematic Reviews (CDSR) Embase MEDLINE Searches will be restricted by: English language Human studies Letters and comments are excluded.

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ID	Field	Content
		Other searches: Inclusion lists of relevant systematic reviews will be checked by the reviewer. The searches may be re-run 6 weeks before final committee meeting and further studies retrieved for inclusion if relevant. The full search strategies will be published in the final review.
5.	Condition or domain being studied	Primary elective joint replacement surgery
6.	Population	Inclusion: Adults awaiting primary elective hip, knee or shoulder joint replacement surgery Exclude studies including people meeting any of the following criteria: Adults having joint replacement as immediate treatment following fracture. Adults having revision joint replacement. Adults having joint replacement as treatment for primary or secondary cancer affecting the bones.
7.	Intervention/Exposure/Test	Individualised preoperative rehabilitation programmes from the time surgery is offered, involving multiple sessions: prescribed and supervised exercises and advice by a member of the rehabilitation team. These programmes could include; provision of equipment, physiotherapy, occupational therapy, nutritional counselling, acupuncture, transcutaneous electrical nerve stimulation, or hydrotherapy.
8.	Comparator/Reference standard/Confounding factors	No formal preoperative rehabilitation or usual care class without individualised program
9.	Types of study to be included	Systematic reviews RCTs If no well-conducted RCTs are available, then observational studies with multivariate analysis will be investigated.
10.	Other exclusion criteria	Non-English language studies. Abstracts will be excluded as it is expected there will be sufficient full text published studies available.

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ID	Field	Content
11.	Context	N/A
12.	Primary outcomes (critical outcomes)	Quality of life within 6 to 24 months (continuous): for example EQ-5D, EQ-VAS Patient Reported Outcome Measures (PROMs) within 6 to 24 months (continuous) Revision of joint replacement (time to event) Depression within 2 years (dichotomous) Disability within 6 to 24 months (continuous)
13.	Secondary outcomes (important outcomes)	Hospital readmissions: within 90 days (dichotomous) Muscle atrophy within 2 years (dichotomous) Length of stay (continuous) To be extracted when not included within an extracted PROM: Function / ADL / return to work within 6 to 24 months (continuous/dichotomous) Pain within 2 years (continuous)
14.	Data extraction (selection and coding)	EndNote will be used for reference management, sifting, citations and bibliographies. Titles and/or abstracts of studies retrieved using the search strategy and those from additional sources will be screened for inclusion. The full text of potentially eligible studies will be retrieved and will be assessed for eligibility in line with the criteria outlined above. 10% of the abstracts will be reviewed by two reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer. An in-house developed database; EviBase, will be used for data extraction. A standardised form is followed to extract data from studies (see Developing NICE guidelines: the manual section 6.4) and for undertaking assessment of study quality. Summary evidence tables will be produced including information on: study setting; study population and participant demographics and baseline characteristics; details of the intervention and control interventions; study methodology' recruitment and missing data rates; outcomes and times of measurement; critical appraisal ratings. A second reviewer will quality assure the extracted data. Discrepancies will be identified and resolved through discussion (with a third reviewer where necessary).
15.	Risk of bias (quality) assessment	Risk of bias will be assessed using the appropriate checklist as described in Developing NICE guidelines: the manual. For Intervention reviews the following checklist will be used according to study design being assessed:

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ID	Field	Content	
		Systematic reviews: Risk of Bias in Systematic Reviews (ROBIS) Randomised Controlled Trial: Cochrane RoB (2.0) Disagreements between the review authors over the risk of bias in particular studies will be resolved by discussion, with involvement of a third review author where necessary.	
16.	Strategy for data synthesis	Where possible, data will be meta-analysed. Pairwise meta-analyses will be performed using Cochrane Review Manager (RevMan5) to combine the data given in all studies for each of the outcomes stated above. A fixed effect meta-analysis, with weighted mean differences for continuous outcomes and risk ratios for binary outcomes will be used, and 95% confidence intervals will be calculated for each outcome. Heterogeneity between the studies in effect measures will be assessed using the I^2 statistic and visually inspected. We will consider an I^2 value greater than 50% indicative of substantial heterogeneity. Sensitivity analyses will be conducted based on pre-specified subgroups using stratified meta-analysis to explore the heterogeneity in effect estimates. If this does not explain the heterogeneity, the results will be presented using random-effects. GRADE pro will be used to assess the quality of each outcome, taking into account individual study quality and the meta-analysis results. The 4 main quality elements (risk of bias, indirectness, inconsistency and imprecision) will be appraised for each outcome. If the population included in an individual study includes children aged under 12, it will be included if the majority of the population is aged over 12, and downgraded for indirectness if the overlap into those aged less than 12 is greater than 20%. Publication bias is tested for when there are more than 5 studies for an outcome. Other bias will only be taken into consideration in the quality assessment if it is apparent. Where meta-analysis is not possible, data will be presented and quality assessed individually per outcome. If sufficient data is available to make a network of treatments, WinBUGS will be used for network meta-analysis.	
17.	Analysis of sub-groups	Site of joint replacement: knee, shoulder, hip	
18.	Type and method of	☒	Intervention

ID	Field	Content			
	review	☐	Diagnostic		
		☐	Prognostic		
		☐	Qualitative		
		☐	Epidemiologic		
		☐	Service Delivery		
		☐	Other (please specify)		
19.	Language	English			
20.	Country	England			
21.	Anticipated or actual start date	18/07/18			
22.	Anticipated completion date	20/03/20			
23.	Stage of review at time of this submission	Review stage		Started	Completed
		Preliminary searches		☑	☐
		Piloting of the study selection process		☑	☐
		Formal screening of search results against eligibility criteria		☐	☐
		Data extraction		☐	☐
		Risk of bias (quality) assessment		☐	☐
		Data analysis		☐	☐
24.	Named contact	5a. Named contact National Guideline Centre 5b Named contact e-mail Headches@nice.org.uk			

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ID	Field	Content
		5e Organisational affiliation of the review National Institute for Health and Care Excellence (NICE) and the National Guideline Centre
25.	Review team members	From the National Guideline Centre: Carlos Sharpin [Guideline lead] Alex Allen [Senior Systematic Reviewer] Rafina Yarde [Systematic reviewer] Robert King [Health economist] Agnès Cuyàs [Information specialist] Eleanor Priestnall [Project Manager]
26.	Funding sources/sponsor	This systematic review is being completed by the National Guideline Centre which receives funding from NICE.
27.	Conflicts of interest	All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.
28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of Developing NICE guidelines: the manual. Members of the guideline committee are available on the NICE website: [NICE guideline webpage].
29.	Other registration details	
30.	Reference/URL for published protocol	
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: notifying registered stakeholders of publication publicising the guideline through NICE's newsletter and alerts issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.

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ID	Field	Content	
32.	Keywords	Knee joint replacement surgery, arthroplasty, preoperative rehabilitation	
33.	Details of existing review of same topic by same authors	N/A	
34.	Current review status	☒	Ongoing
		☐	Completed but not published
		☐	Completed and published
		☐	Completed, published and being updated
		☐	Discontinued
35..	Additional information	N/A	
36.	Details of final publication	www.nice.org.uk	

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Table 7: Health economic review protocol

Review question	All questions – health economic evidence
Objectives	To identify health economic studies relevant to any of the review questions.
Search criteria	• Populations, interventions and comparators must be as specified in the clinical review protocol above. • Studies must be of a relevant health economic study design (cost–utility analysis, cost-effectiveness analysis, cost–benefit analysis, cost–consequences analysis, comparative cost analysis). • Studies must not be a letter, editorial or commentary, or a review of health economic evaluations. (Recent reviews will be ordered although not reviewed. The bibliographies will be checked for relevant studies, which will then be ordered.) • Unpublished reports will not be considered unless submitted as part of a call for evidence. • Studies must be in English.
Search strategy	A health economic study search will be undertaken using population-specific terms and a health economic study filter – see appendix B below.
Review strategy	Studies not meeting any of the search criteria above will be excluded. Studies published before 2003, abstract-only studies and studies from low or middle-income countries (e.g. non-OECD countries) or the USA will also be excluded. Each remaining study will be assessed for applicability and methodological limitations using the NICE economic evaluation checklist which can be found in appendix H of Developing NICE guidelines: the manual (2014).[63] **Inclusion and exclusion criteria** • If a study is rated as both 'Directly applicable' and with 'Minor limitations', then it will be included in the guideline. A health economic evidence table will be completed and it will be included in the health economic evidence profile. • If a study is rated as either 'Not applicable' or with 'Very serious limitations' then it will usually be excluded from the guideline. If it is excluded then a health economic evidence table will not be completed and it will not be included in the health economic evidence profile. • If a study is rated as 'Partially applicable', with 'Potentially serious limitations' or both then there is discretion over whether it should be included. **Where there is discretion** The health economist will make a decision based on the relative applicability and quality of the available evidence for that question, in discussion with the guideline committee if required. The ultimate aim is to include health economic studies that are helpful for decision-making in the context of the guideline and the current NHS setting. If several studies are considered of sufficiently high applicability and methodological quality that they could all be included, then the health economist, in discussion with the committee if required, may decide to include only the most applicable studies and to exclude the remaining studies selectively. All studies excluded based on applicability or methodological limitations will be listed with explanation in the excluded health economic studies appendix below. The health economist will be guided by the following hierarchies. *Setting:* • UK NHS (most applicable). • OECD countries with predominantly public health insurance systems (for example, France, Germany, Sweden). • OECD countries with predominantly private health insurance systems (for example,

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	Switzerland). • Studies set in non-OECD countries or in the USA will be excluded before being assessed for applicability and methodological limitations. *Health economic study type:* • Cost–utility analysis (most applicable). • Other type of full economic evaluation (cost–benefit analysis, cost-effectiveness analysis, cost–consequences analysis). • Comparative cost analysis. • Non-comparative cost analyses including cost-of-illness studies will be excluded before being assessed for applicability and methodological limitations. *Year of analysis:* • The more recent the study, the more applicable it will be. • Studies published in 2003 or later but that depend on unit costs and resource data entirely or predominantly before 2003 will be rated as 'Not applicable'. • Studies published before 2003 will be excluded before being assessed for applicability and methodological limitations. *Quality and relevance of effectiveness data used in the health economic analysis:* • The more closely the clinical effectiveness data used in the health economic analysis match with the outcomes of the studies included in the clinical review the more useful the analysis will be for decision-making in the guideline.

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Appendix B: Literature search strategies

The literature searches for this review are detailed below and complied with the methodology outlined in Developing NICE guidelines: the manual.[63]

For more detailed information, please see the Methodology Review.

B.1 Clinical search literature search strategy

Searches were constructed using a PICO framework where population (P) terms were combined with Intervention (I) and in some cases Comparison (C) terms. Outcomes (O) are rarely used in search strategies for interventions as these concepts may not be well described in title, abstract or indexes and therefore difficult to retrieve. Search filters were applied to the searches where appropriate.

Table 8: Database date parameters and filters used

Database	Dates searched	Search filter used
Medline (OVID)	1946 – 01 May 2019	Exclusions Randomised controlled trials Systematic review studies Observational studies
Embase (OVID)	1974 – 01 May 2019	Exclusions Randomised controlled trials Systematic review studies Observational studies
The Cochrane Library (Wiley)	Cochrane Reviews to 2019 Issue 5 of 12 CENTRAL to 2019 Issue 5 of 12 DARE, and NHSEED to 2015 Issue 2 of 4 HTA to 2016 Issue 4 of 4	None

Medline (Ovid) search terms

1.	arthroplasty/ or arthroplasty, replacement/ or arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/ or arthroplasty, replacement, shoulder/ or hemiarthroplasty/
2.	joint prosthesis/ or hip prosthesis/ or knee prosthesis/ or shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter/
6.	editorial/
7.	news/
8.	exp historical article/
9.	Anecdotes as Topic/
10.	comment/
11.	case report/
12.	(letter or comment*).ti.
13.	or/5-12
14.	randomized controlled trial/ or random*.ti,ab.

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15.	13 not 14
16.	animals/ not humans/
17.	exp Animals, Laboratory/
18.	exp Animal Experimentation/
19.	exp Models, Animal/
20.	exp Rodentia/
21.	(rat or rats or mouse or mice).ti.
22.	or/15-21
23.	4 not 22
24.	limit 23 to English language
25.	exp Rehabilitation/
26.	Rehabilitation Nursing/
27.	rehab*.ti,ab.
28.	(prehabilitat* or pre habilitat*).ti,ab.
29.	Early Ambulation/
30.	(early adj3 (ambulation or mobili*)).ti,ab.
31.	Physical Therapy Modalities/
32.	exp Exercise Therapy/ or Physical Conditioning, Human/ or Occupational Therapy/ or Recreation Therapy/ or Rehabilitation, Vocational/
33.	Motion Therapy, Continuous Passive/ or Muscle Stretching Exercises/ or Manipulation, Orthopedic/ or Resistance Training/
34.	((physical* or exercise* or motion or movement or occupational or recreation* or vocational) adj3 (therap* or condition*)).ti,ab.
35.	(manipulation or MUA).ti,ab.
36.	((standardi?ed or SE or continuous passive motion or CPM or slider board or SB or range of motion or ROM or resistance or weight bearing or equilibrium or flexibility or stretch*) adj2 (therap* or exercise*)).ti,ab.
37.	physiotherap*.ti,ab.
38.	Hydrotherapy/
39.	(hydrotherap* or aquatic physiotherap*).ti,ab.
40.	Transcutaneous Electric Nerve Stimulation/
41.	(electric* nerve stimulation or TENS).ti,ab.
42.	Patient Education as Topic/
43.	(patient* adj3 (education or information or advice)).ti,ab.
44.	or/25-43
45.	24 and 44
46.	randomized controlled trial.pt.
47.	controlled clinical trial.pt.
48.	randomi#ed.ti,ab.
49.	placebo.ab.
50.	randomly.ti,ab.
51.	Clinical Trials as topic.sh.
52.	trial.ti.
53.	or/46-52
54.	Meta-Analysis/
55.	exp Meta-Analysis as Topic/

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56.	(meta analy* or metanaly* or metaanaly* or meta regression).ti,ab.
57.	((systematic* or evidence*) adj3 (review* or overview*)).ti,ab.
58.	(reference list* or bibliograph* or hand search* or manual search* or relevant journals).ab.
59.	(search strategy or search criteria or systematic search or study selection or data extraction).ab.
60.	(search* adj4 literature).ab.
61.	(medline or pubmed or cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or science citation index or bids or cancerlit).ab.
62.	cochrane.jw.
63.	((multiple treatment* or indirect or mixed) adj2 comparison*).ti,ab.
64.	or/54-63
65.	Epidemiologic studies/
66.	Observational study/
67.	exp Cohort studies/
68.	(cohort adj (study or studies or analys* or data)).ti,ab.
69.	((follow up or observational or uncontrolled or non randomi#ed or epidemiologic*) adj (study or studies or data)).ti,ab.
70.	((longitudinal or retrospective or prospective or cross sectional) and (study or studies or review or analys* or cohort* or data)).ti,ab.
71.	Controlled Before-After Studies/
72.	Historically Controlled Study/
73.	Interrupted Time Series Analysis/
74.	(before adj2 after adj2 (study or studies or data)).ti,ab.
75.	or/65-74
76.	exp case control study/
77.	case control*.ti,ab.
78.	or/76-77
79.	75 or 78
80.	Cross-sectional studies/
81.	(cross sectional and (study or studies or review or analys* or cohort* or data)).ti,ab.
82.	or/80-81
83.	75 or 82
84.	75 or 78 or 82
85.	45 and (53 or 64 or 84)

Embase (Ovid) search terms

1.	*arthroplasty/ or *replacement arthroplasty/ or *hip replacement/ or *knee replacement/ or *shoulder replacement/ or *hemiarthroplasty/
2.	*joint prosthesis/ or *hip prosthesis/ or *knee prosthesis/ or *shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter.pt. or letter/
6.	note.pt.
7.	editorial.pt.
8.	case report/ or case study/
9.	(letter or comment*).ti.

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10.	or/5-9
11.	randomized controlled trial/ or random*.ti,ab.
12.	10 not 11
13.	animal/ not human/
14.	nonhuman/
15.	exp Animal Experiment/
16.	exp Experimental Animal/
17.	animal model/
18.	exp Rodent/
19.	(rat or rats or mouse or mice).ti.
20.	or/12-19
21.	4 not 20
22.	limit 21 to English language
23.	exp rehabilitation/
24.	rehabilitation nursing/
25.	rehab*.ti,ab.
26.	(prehabilitat* or pre habilitat*).ti,ab.
27.	*mobilization/
28.	(early adj3 (ambulation or mobili*)).ti,ab.
29.	*physiotherapy/ or *kinesiotherapy/ or *exercise/ or *occupational therapy/ or *recreational therapy/ or *vocational rehabilitation/
30.	*movement therapy/ or *stretching exercise/ or *orthopedic manipulation/ or *resistance training/
31.	((physical* or exercise* or motion or movement or occupational or recreation* or vocational) adj3 (therap* or condition*)).ti,ab.
32.	(manipulation or MUA).ti,ab.
33.	((standardi?ed or SE or continuous passive motion or CPM or slider board or SB or range of motion or ROM or resistance or weight bearing or equilibrium or flexibility or stretch*) adj2 (therap* or exercise*)).ti,ab.
34.	physiotherap*.ti,ab.
35.	hydrotherapy/
36.	(hydrotherap* or aquatic physiotherap*).ti,ab.
37.	transcutaneous electrical nerve stimulation/
38.	(electric* nerve stimulation or TENS).ti,ab.
39.	*patient education/
40.	(patient* adj3 (education or information or advice)).ti,ab.
41.	or/23-40
42.	22 and 41
43.	random*.ti,ab.
44.	factorial*.ti,ab.
45.	(crossover* or cross over*).ti,ab.
46.	((doubl* or singl*) adj blind*).ti,ab.
47.	(assign* or allocat* or volunteer* or placebo*).ti,ab.
48.	crossover procedure/
49.	single blind procedure/
50.	randomized controlled trial/

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51.	double blind procedure/
52.	or/43-51
53.	systematic review/
54.	meta-analysis/
55.	(meta analy* or metanaly* or metaanaly* or meta regression).ti,ab.
56.	((systematic* or evidence*) adj3 (review* or overview*)).ti,ab.
57.	(reference list* or bibliograph* or hand search* or manual search* or relevant journals).ab.
58.	(search strategy or search criteria or systematic search or study selection or data extraction).ab.
59.	(search* adj4 literature).ab.
60.	(medline or pubmed or cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or science citation index or bids or cancerlit).ab.
61.	cochrane.jw.
62.	((multiple treatment* or indirect or mixed) adj2 comparison*).ti,ab.
63.	or/53-62
64.	Clinical study/
65.	Observational study/
66.	family study/
67.	longitudinal study/
68.	retrospective study/
69.	prospective study/
70.	cohort analysis/
71.	follow-up/
72.	cohort*.ti,ab.
73.	71 and 72
74.	(cohort adj (study or studies or analys* or data)).ti,ab.
75.	((follow up or observational or uncontrolled or non randomi#ed or epidemiologic*) adj (study or studies or data)).ti,ab.
76.	((longitudinal or retrospective or prospective or cross sectional) and (study or studies or review or analys* or cohort* or data)).ti,ab.
77.	(before adj2 after adj2 (study or studies or data)).ti,ab.
78.	or/64-70,73-77
79.	exp case control study/
80.	case control*.ti,ab.
81.	or/79-80
82.	78 or 81
83.	cross-sectional study/
84.	(cross sectional and (study or studies or review or analys* or cohort* or data)).ti,ab.
85.	or/83-84
86.	78 or 85
87.	78 or 81 or 85
88.	42 and (52 or 63 or 87)

Cochrane Library (Wiley) search terms

#1.	MeSH descriptor: [Arthroplasty] this term only
#2.	MeSH descriptor: [Arthroplasty, Replacement] this term only

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#3.	MeSH descriptor: [Arthroplasty, Replacement, Hip] this term only
#4.	MeSH descriptor: [Arthroplasty, Replacement, Knee] this term only
#5.	MeSH descriptor: [Arthroplasty, Replacement, Shoulder] this term only
#6.	MeSH descriptor: [Hemiarthroplasty] this term only
#7.	(or #1-#6)
#8.	MeSH descriptor: [Joint Prosthesis] this term only
#9.	MeSH descriptor: [Hip Prosthesis] this term only
#10.	MeSH descriptor: [Knee Prosthesis] this term only
#11.	MeSH descriptor: [Shoulder Prosthesis] this term only
#12.	(or #8-#11)
#13.	((joint* or knee* or shoulder* or hip*) near/5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)):ti,ab
#14.	(or #7, #12-#13)
#15.	MeSH descriptor: [Rehabilitation] explode all trees
#16.	MeSH descriptor: [Rehabilitation Nursing] explode all trees
#17.	rehab*:ti,ab
#18.	(prehabilitat* or pre habilitat*):ti,ab
#19.	MeSH descriptor: [Early Ambulation] this term only
#20.	(early near/3 (ambulation or mobili*)):ti,ab
#21.	MeSH descriptor: [Physical Therapy Modalities] this term only
#22.	MeSH descriptor: [Exercise Therapy] explode all trees
#23.	MeSH descriptor: [Physical Conditioning, Human] this term only
#24.	MeSH descriptor: [Occupational Therapy] this term only
#25.	MeSH descriptor: [Recreation Therapy] this term only
#26.	MeSH descriptor: [Rehabilitation, Vocational] this term only
#27.	MeSH descriptor: [Motion Therapy, Continuous Passive] this term only
#28.	MeSH descriptor: [Muscle Stretching Exercises] this term only
#29.	MeSH descriptor: [Manipulation, Orthopedic] this term only
#30.	MeSH descriptor: [Resistance Training] this term only
#31.	((physical* or exercise* or motion or movement or occupational or recreation* or vocational) near/3 (therap* or condition*)):ti,ab
#32.	(manipulation or MUA):ti,ab
#33.	((standardised or standardized or SE or continuous passive motion or CPM or slider board or SB or range of motion or ROM or resistence or weight bearing or equilibrium or flexibility or stretch*) near/2 (therap* or exercise*)):ti,ab
#34.	physiotherap*:ti,ab
#35.	MeSH descriptor: [Hydrotherapy] this term only
#36.	(hydrotherap* or aquatic physiotherap*):ti,ab
#37.	MeSH descriptor: [Transcutaneous Electric Nerve Stimulation] this term only
#38.	(electric* nerve stimulation or TENS):ti,ab
#39.	MeSH descriptor: [Patient Education as Topic] this term only
#40.	(patient* near/3 (education or information or advice)):ti,ab
#41.	(or #15-#40)
#42.	#14 and #41

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B.2 Health Economics literature search strategy

Health economic evidence was identified by conducting a broad search relating to the joint replacement population in NHS Economic Evaluation Database (NHS EED – this ceased to be updated after March 2015) and the Health Technology Assessment database (HTA) with no date restrictions. NHS EED and HTA databases are hosted by the Centre for Research and Dissemination (CRD). Additional health economic searches were run in Medline and Embase.

Table 9: Database date parameters and filters used

Database	Dates searched	Search filter used
Medline	2014 – 01 May 2019	Exclusions Health economics studies
Embase	2014 – 01 May 2019	Exclusions Health economics studies
Centre for Research and Dissemination (CRD)	HTA - Inception – 01 May 2019 NHSEED - Inception to March 2015	None

Medline (Ovid) search terms

1.	arthroplasty/ or arthroplasty, replacement/ or arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/ or arthroplasty, replacement, shoulder/ or hemiarthroplasty/
2.	joint prosthesis/ or hip prosthesis/ or knee prosthesis/ or shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter/
6.	editorial/
7.	news/
8.	exp historical article/
9.	Anecdotes as Topic/
10.	comment/
11.	case report/
12.	(letter or comment*).ti.
13.	or/5-12
14.	randomized controlled trial/ or random*.ti,ab.
15.	13 not 14
16.	animals/ not humans/
17.	exp Animals, Laboratory/
18.	exp Animal Experimentation/
19.	exp Models, Animal/
20.	exp Rodentia/
21.	(rat or rats or mouse or mice).ti.
22.	or/15-21
23.	4 not 22
24.	limit 23 to English language

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25.	Economics/
26.	Value of life/
27.	exp "Costs and Cost Analysis"/
28.	exp Economics, Hospital/
29.	exp Economics, Medical/
30.	Economics, Nursing/
31.	Economics, Pharmaceutical/
32.	exp "Fees and Charges"/
33.	exp Budgets/
34.	budget*.ti,ab.
35.	cost*.ti.
36.	(economic* or pharmaco?economic*).ti.
37.	(price* or pricing*).ti,ab.
38.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
39.	(financ* or fee or fees).ti,ab.
40.	(value adj2 (money or monetary)).ti,ab.
41.	or/25-40
42.	24 and 41

Embase (Ovid) search terms

1.	*arthroplasty/ or *replacement arthroplasty/ or *hip replacement/ or *knee replacement/ or *shoulder replacement/ or *hemiarthroplasty/
2.	*joint prosthesis/ or *hip prosthesis/ or *knee prosthesis/ or *shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter.pt. or letter/
6.	note.pt.
7.	editorial.pt.
8.	case report/ or case study/
9.	(letter or comment*).ti.
10.	or/5-9
11.	randomized controlled trial/ or random*.ti,ab.
12.	10 not 11
13.	animal/ not human/
14.	nonhuman/
15.	exp Animal Experiment/
16.	exp Experimental Animal/
17.	animal model/
18.	exp Rodent/
19.	(rat or rats or mouse or mice).ti.
20.	or/12-19
21.	4 not 20

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22.	limit 21 to English language
23.	health economics/
24.	exp economic evaluation/
25.	exp health care cost/
26.	exp fee/
27.	budget/
28.	funding/
29.	budget*.ti,ab.
30.	cost*.ti.
31.	(economic* or pharmaco?economic*).ti.
32.	(price* or pricing*).ti,ab.
33.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
34.	(financ* or fee or fees).ti,ab.
35.	(value adj2 (money or monetary)).ti,ab.
36.	or/23-35
37.	22 and 36

NHS EED and HTA (CRD) search terms

#1.	MeSH DESCRIPTOR arthroplasty
#2.	MeSH DESCRIPTOR arthroplasty, replacement
#3.	MeSH DESCRIPTOR arthroplasty, replacement, hip
#4.	MeSH DESCRIPTOR arthroplasty, replacement, knee
#5.	MeSH DESCRIPTOR arthroplasty, replacement, shoulder
#6.	MeSH DESCRIPTOR hemiarthroplasty
#7.	MeSH DESCRIPTOR joint prosthesis
#8.	MeSH DESCRIPTOR hip prosthesis
#9.	MeSH DESCRIPTOR knee prosthesis
#10.	MeSH DESCRIPTOR shoulder prosthesis
#11.	(((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)))
#12.	(#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11) IN NHSEED
#13.	(#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11) IN HTA

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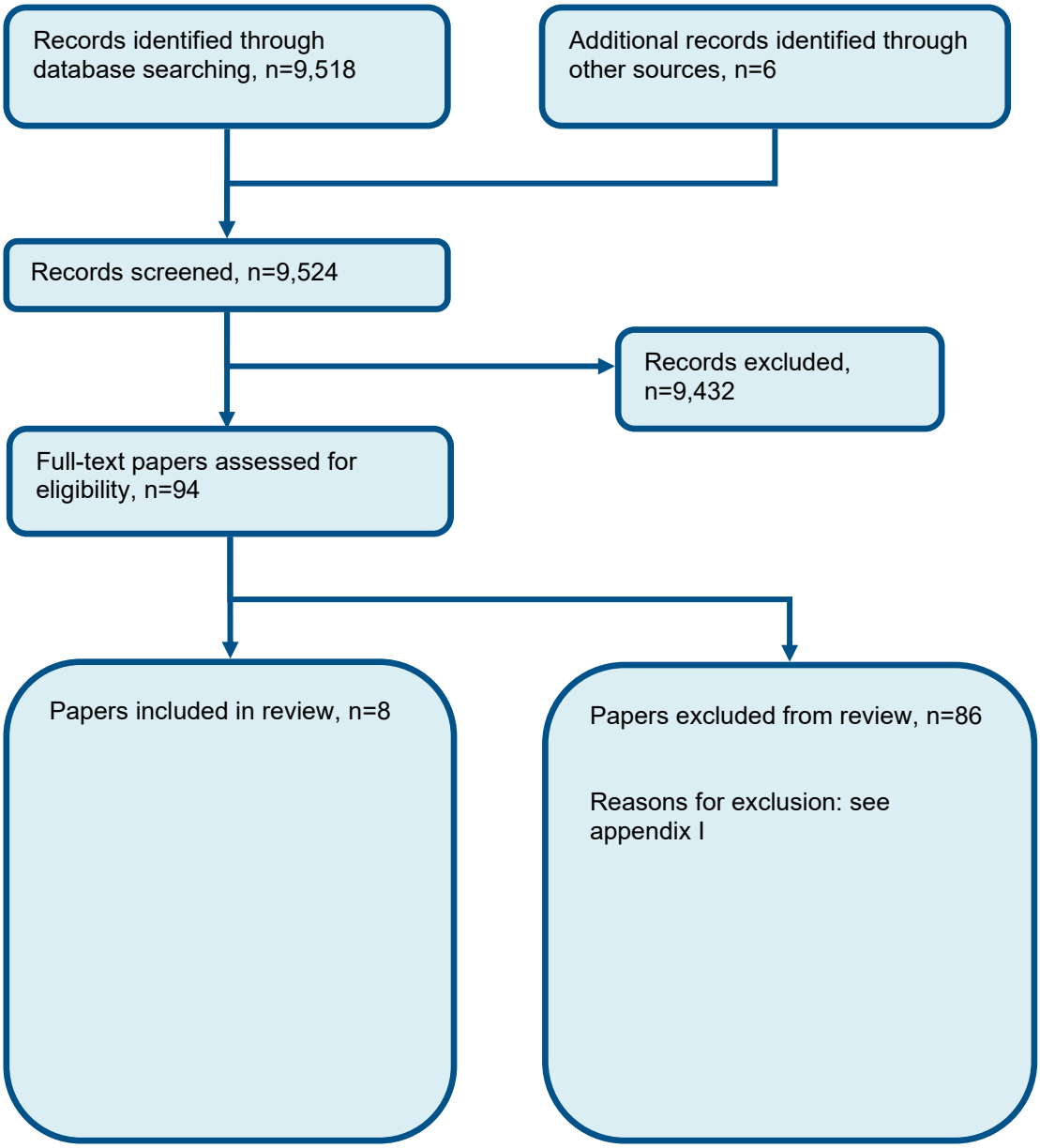
Appendix C: Clinical evidence selection

Figure 1: Flow chart of clinical study selection for the review of preoperative rehabilitation



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Appendix D: Clinical evidence tables

Study	Beaupre 2004[5]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=131)
Countries and setting	Conducted in Canada; Setting: University of Alberta hospitals
Line of therapy	Adjunctive to current care
Duration of study	Intervention + follow up: 6 week intervention and 1 year follow-up
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: People on a waiting list for total knee replacement
Stratum	Overall
Subgroup analysis within study	Not applicable
Inclusion criteria	Booked for total knee arthroplasty, diagnosis of non-inflammatory arthritis, between 40 and 75 years old, ability to comprehend verbal or written English or have a translator.
Exclusion criteria	Not detailed
Recruitment/selection of patients	From the waiting list for total knee arthroplasty
Age, gender and ethnicity	Age - Mean (SD): 67 (7). Gender (M:F): 59/72. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Knee
Indirectness of population	No indirectness
Interventions	(n=65) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team. Education: crutch walking, bed mobility and transfers, postoperative ROM routine. Exercise: designed to improve knee mobility and strength. Strengthening and resistance depending on patient tolerance. Warm up and cool-down included. . Duration 3 attendances per week for 4 weeks. (12 sessions). . Concurrent medication/care: After surgery, standard postoperative mobilization routine. Indirectness: No indirectness (n=66) Intervention 2: No formal preoperative rehabilitation or usual care - No formal preoperative rehabilitation or usual care class without individualised program. Continued regular activities until surgery. .

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	Duration 6 weeks with 1-year follow-up. Concurrent medication/care: After surgery, standard postoperative mobilization routine was followed.. Indirectness: No indirectness
Funding	Funding not stated

RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: INDIVIDUALISED PREOPERATIVE REHABILITATION PROGRAMME versus USUAL CARE WITHOUT INDIVIDUALISED PROGRAM

Protocol outcome 1: Quality of life at within 6 to 24 months
- Actual outcome: Quality of life: SF36: physical component summary at 1 year postoperative; Group 1: mean 38 (SD 8); n=51, Group 2: mean 41 (SD 10); n=58; SF36: PCS 0-100 Top=High is good outcome
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: More people with comorbid conditions in the control group. ; Group 1 Number missing: 14, Reason: 10 cancelled surgery, 2 withdrew from study, 2 died; Group 2 Number missing: 8, Reason: 6 cancelled surgery, 2 withdrew from study,
- Actual outcome: Quality of life: SF36: mental component summary at 1 year postoperative; Group 1: mean 56 (SD 9); n=51, Group 2: mean 58 (SD 7); n=58; SF36 MCS 0-100 Top=High is good outcome
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: More people with comorbid conditions in the control group. ; Group 1 Number missing: 14, Reason: 10 cancelled surgery, 2 withdrew from study, 2 died; Group 2 Number missing: 8, Reason: 6 cancelled surgery, 2 withdrew from study,

Protocol outcome 2: Patient Reported Outcome Measures (PROMs) at within 6 to 24 months
- Actual outcome: PROMs: WOMAC pain score at 1 year postoperative; Group 1: mean 82 (SD 13); n=51, Group 2: mean 80 (SD 16); n=58; WOMAC pain score 0-100 transformed from Likert scale Top=High is good outcome
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: More people with comorbid conditions in the control group. ; Group 1 Number missing: 14, Reason: 10 cancelled surgery, 2 withdrew from study, 2 died; Group 2 Number missing: 8, Reason: 6 cancelled surgery, 2 withdrew from study,
- Actual outcome: PROMs: WOMAC stiffness score at 1 year postoperative; Group 1: mean 67 (SD 18); n=51, Group 2: mean 71 (SD 21); n=58; WOMAC stiffness score 0-100 transformed from Likert scale Top=High is good outcome
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: More people with comorbid conditions in the control group. ; Group 1 Number missing: 14, Reason: 10 cancelled surgery, 2 withdrew from study, 2 died; Group 2 Number missing: 8, Reason: 6 cancelled surgery, 2 withdrew from study,
- Actual outcome: PROMs: WOMAC function score at 1 year postoperative; Group 1: mean 77 (SD 14); n=51, Group 2: mean 77 (SD 16); n=58; WOMAC function score 0-100 transformed from Likert scale Top=High is good outcome
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: More people with comorbid conditions in the control group. ; Group 1 Number missing: 14, Reason: 10 cancelled surgery, 2 withdrew from study, 2 died; Group 2 Number missing: 8, Reason: 6 cancelled

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surgery, 2 withdrew from study, Protocol outcome 3: Length of stay at time to event - Actual outcome: Length of stay in surgical hospital at .; Group 1: mean 6.7 days (SD 2.2); n=55, Group 2: mean 7.3 days (SD 2.5); n=60 Risk of bias: All domain - ; Indirectness of outcome: No indirectness	
Protocol outcomes not reported by the study	Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Function / ADL / return to work at within 6 to 24 months; Pain at within 24 months

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Study	Berge 2004[6]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=40)
Countries and setting	Conducted in United Kingdom; Setting: Orthopaedic department at St Richard's Hospital, Chichester, UK.
Line of therapy	Adjunctive to current care
Duration of study	Intervention + follow up: Intervention for 6 week, follow-up for 6 months after surgery.
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: People on a waiting list for hip replacement
Stratum	Overall
Subgroup analysis within study	Not applicable
Inclusion criteria	On waiting list for hip replacement for 6 to 18 months.
Exclusion criteria	Not detailed.
Recruitment/selection of patients	Unclear
Age, gender and ethnicity	Age - Mean (SD): Intervention: 72 (6), control: 71 (6). Gender (M:F): 13/27. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Hip
Indirectness of population	No indirectness
Interventions	(n=23) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . Pain management Programme (PMP): educating people on arthritis, hip function and general health issues. Behaviour change, where considered necessary, in terms of exercise, joint protection and pacing activity. Exercise component emphasised throughout program. Utilising cognitive methods to address fears and frustrations alongside relaxation techniques to improve quality of life, sleep and activity. . Duration 6-week period prior to surgery. Concurrent medication/care: Taught muscle toning exercises, written materials on pain, osteoarthritis and joint replacement. Advice given on the postoperative period. . Indirectness: No indirectness (n=21) Intervention 2: No formal preoperative rehabilitation or usual care - No formal preoperative rehabilitation or usual care class without individualised program. No additional treatment outside of background. . Duration 6 weeks prior to surgery. Concurrent medication/care: Taught muscle toning exercises, written materials on pain, osteoarthritis and joint replacement. Advice given on the postoperative period.. Indirectness: No indirectness
Funding	Funding not stated

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RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: INDIVIDUALISED PREOPERATIVE REHABILITATION PROGRAM versus USUAL CARE Protocol outcome 1: Function / ADL / return to work at within 6 to 24 months - Actual outcome: Function via Arthritis Impact Measurement Scales (AIMS): total score at Median: 8 months after surgery; Group 1: mean 42.89 (SD 8.44); n=18, Group 2: mean 49.12 (SD 8.44); n=15; AIMS 0-90 Top=High is poor outcome; Comments: SD calculated from p value Risk of bias: All domain - Very high, Selection - High, Blinding - High, Incomplete outcome data - High, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: Pain higher in control group. ; Group 1 Number missing: 5, Reason: 4 did not receive PMP due to 1 changing to private care, 3 refused to start trial. 1 lost to follow-up due to stroke. ; Group 2 Number missing: 6, Reason: 3 had op early and lost to follow-up, 3 more lost to follow-up due to death, stroke and move to private health care Protocol outcome 2: Pain at within 24 months - Actual outcome: Pain intensity at Median: 8 months after surgery; Group 1: mean 2.36 (SD 3.09); n=18, Group 2: mean 3.2 (SD 3.17); n=15; Numerical rating scale 0-10 Top=High is poor outcome Risk of bias: All domain - Very high, Selection - High, Blinding - High, Incomplete outcome data - High, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: Pain higher in control group. ; Group 1 Number missing: 5, Reason: 4 did not receive PMP due to 1 changing to private care, 3 refused to start trial. 1 lost to follow-up due to stroke. ; Group 2 Number missing: 6, Reason: 3 had op early and lost to follow-up, 3 more lost to follow-up due to death, stroke and move to private health care	
Protocol outcomes not reported by the study	Quality of life at within 6 to 24 months; Patient Reported Outcome Measures (PROMs) at within 6 to 24 months; Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Length of stay at time to event

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Study	Crowe 2003[23]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=133)
Countries and setting	Conducted in Canada
Line of therapy	Adjunctive to current care
Duration of study	Not clear: Median start time was 6 weeks before surgery
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: People scheduled for total hip or knee joint arthroplasty
Stratum	Overall
Subgroup analysis within study	Not applicable
Inclusion criteria	People who were scheduled for elective hip or knee arthroplasty and not functioning well because of joint dysfunction, and who had limited social support, and/or comorbid medical conditions.
Exclusion criteria	People who were functioning well despite joint dysfunction, and were managing their activities of daily living well with good caregiver support. Clients with limited English language skills or marked cognition problems, receiving their joint replacement as management for cancer, and undergoing a revision or second joint replacement in less than two years.
Age, gender and ethnicity	Age - Mean (SD): Intervention group: 71 (11). Control group: 67 (12) . . Gender (M:F): 27/106. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Hip and Knee
Indirectness of population	No indirectness
Interventions	(n=65) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . Assessed by an occupational therapist, physiotherapist or nurse and a program was formulated based on needs. Given a preoperative education package: video, booklet, information on length of stay, discharge criteria, respite care and diet. Physical conditioning program was available which focused on improving strength and endurance to facilitate post-operative mobility. All subjects received extensive individualized counselling from an occupational therapist. . Duration Between 1 and 24 weeks prior to surgery. Most common time was 6 weeks. Rehab began once joint replacement surgery was scheduled. . Concurrent medication/care: Support provided where required: tours of the post-operative hospital unit, demonstrations as to how to use equipment and small adaptive equipment provided as required, dietitian counselling, pharmacy (for those with complex medication requirements) and social work input.. Indirectness: Serious indirectness; Indirectness comment: Unclear how many participants received physical conditioning program

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	(n=68) Intervention 2: No formal preoperative rehabilitation or usual care - No formal preoperative rehabilitation or usual care class without individualised program. One standard preoperative clinic visit. People were educated about what to bring to hospital, instructions about preoperative medication and bowel preparation, and received some information about the hospital stay and the immediate post-operative phase. This included education about the functional implications of surgery and temporary functional post-operative limitations.. Duration 7-hour appointment: one to two weeks prior to the surgery. Concurrent medication/care: None detailed. Indirectness: No indirectness
Funding	Academic or government funding (Hamilton Health Sciences Foundation)
RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: INDIVIDUALISED PREOPERATIVE REHABILITATION PROGRAM versus USUAL CARE WITHOUT INDIVIDUALISED PROGRAM Protocol outcome 1: Length of stay at time to event - Actual outcome: Length of stay at Until discharge from hospital; Group 1: mean 6.55 days (SD 4.2); n=65, Group 2: mean 10.5 days (SD 14.2); n=68 Risk of bias: All domain - Low, Selection - Low, Blinding - Low, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: Similar for Oxford score, age, gender, osteoarthritis, procedure. ; Group 1 Number missing: ; Group 2 Number missing:	
Protocol outcomes not reported by the study	Quality of life at within 6 to 24 months; Patient Reported Outcome Measures (PROMs) at within 6 to 24 months; Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Function / ADL / return to work at within 6 to 24 months; Pain at within 24 months

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Study	Doiron-Cadrin 2019[30]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=34)
Countries and setting	Conducted in Canada; Setting:
Line of therapy	Not applicable
Duration of study	Intervention time: 12 weeks
Method of assessment of guideline condition	Adequate method of assessment/diagnosis
Stratum	Overall
Subgroup analysis within study	Not applicable
Inclusion criteria	Adults waiting for TKA or THA suffering from severe OA. People were required to speak French and to have access to high-speed internet.
Exclusion criteria	Inflammatory arthritis, bilateral surgery, lower limb surgery in previous 6 months, scheduled for revision of previous joint replacement, large diameter hip prosthesis planned, severe psychiatric, neurologic or cardiac disorder.
Recruitment/selection of patients	People on a waiting list for hip or knee replacement surgery at Maisonneuve-Rosemont Hospital (HMR) or Santa-Cabrini hospital (HSC).
Age, gender and ethnicity	Age - Mean (SD): 70 (9), 61 (8), 67 (9). Gender (M:F): 9/25. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Hip and Knee
Indirectness of population	No indirectness
Interventions	(n=12) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . 12 week program with 2 in-person supervised physiotherapy sessions each week and people were required to complete an exercise log book. Tailored prescription of exercises while monitoring pain, function and tolerance. Exercises aimed to increase range of motion of strength hip or knee muscles. Proprioceptive exercises, cardiovascular warm up, education regarding medication usage, and ice application. . Duration 12 weeks. Concurrent medication/care: None detailed. Indirectness: No indirectness (n=11) Intervention 2: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . 12 week program with 2 telecommunication supervised physiotherapy sessions each

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	week and people were required to complete an exercise log book. Tailored prescription of exercises while monitoring pain, function and tolerance. Exercises aimed to increase range of motion of strength hip or knee muscles. Proprioceptive exercises, cardiovascular warm up, education regarding medication usage, and ice application. . Duration 12 weeks. Concurrent medication/care: None detailed. Indirectness: No indirectness (n=11) Intervention 3: No formal preoperative rehabilitation or usual care - No formal preoperative rehabilitation or usual care class without individualised program. Usual care without prehabilitation. This involved a single home visit from a community-based physiotherapist and the person is given an information booklet on surgery, medication, and rehabilitation. . Duration Single home visit. Concurrent medication/care: None detailed. Indirectness: No indirectness
Funding	Academic or government funding (Francois Desmeules'Fonds de Recherche du Quebec - Sante (FRQS) and the Ordre Professionel de la physiotherapie du Quebec)
Protocol outcomes not reported by the study	Quality of life at within 6 to 24 months; Patient Reported Outcome Measures (PROMs) at within 6 to 24 months; Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Length of stay at time to event; Function / ADL / return to work at within 6 to 24 months; Pain at within 24 months

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Study	Ferrara 2008[33]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=23)
Countries and setting	Conducted in Italy; Setting: Orthopaedic Department of the University Hospital 'Agostino Gemelli' of Rome.
Line of therapy	Adjunctive to current care
Duration of study	Intervention + follow up: 15 days intervention and 3 months follow-up
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: People on the waiting list for a total hip replacement
Stratum	Overall
Subgroup analysis within study	Not applicable
Inclusion criteria	On waiting list for total hip replacement surgery, end-stage osteoarthritis
Exclusion criteria	Cognitive deterioration evaluated with a Mini-Mental State Examination, the presence of other joint prosthesis, hip congenital dysplasia, inflammatory arthritis (rheumatoid arthritis, systematic lupus erythematosus), Parkinson's disease and sensitive neuropathy.
Age, gender and ethnicity	Age - Mean (SD): Intervention group: 64 (9), control group: 63 (7). Gender (M:F): 9/14. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Hip (THR).
Indirectness of population	No indirectness
Interventions	(n=11) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . One month prior to surgery, the study group took part in a physiotherapy program consisting of group and individual exercises for five days/week with some physical therapist contact. Advice given on the movements that should be avoided, preventing the dislocation of prostheses, the use of devices (crutches, elevated toilet seats, elevated beds and forceps to help in dressing and undressing), correct posture, lifting and carrying, washing and bathing.. Duration 1 month. Concurrent medication/care: The post-surgery inpatient rehabilitation program was undertaken for four weeks.. Indirectness: No indirectness (n=12) Intervention 2: No formal preoperative rehabilitation or usual care - No formal preoperative rehabilitation or usual care class without individualised program. Exercise undertaken after surgery. Duration Unclear. Concurrent medication/care: Post-surgery inpatient rehabilitation program was undertaken for four weeks.. Indirectness: No indirectness
Funding	Funding not stated

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RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: INDIVIDUALISED PREOPERATIVE REHABILITATION PROGRAM versus USUAL CARE WITHOUT INDIVIDUALISED PROGRAM Protocol outcome: Pain at within 24 months - Actual outcome: Change in pain (VAS) at 3 months after surgery; Group 1: mean -6.8 (SD 1.84); n=11, Group 2: mean -6.27 (SD 1.73); n=12; Visual Analogue Scale (VAS) 0-10 Top=High is poor outcome Risk of bias: All domain - Very high, Selection - High, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness; Baseline details: Function better in the control group, Harris Hip Score better in the intervention group; Group 1 Number missing: ; Group 2 Number missing:	
Protocol outcomes not reported by the study	Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Length of stay at time to event; Function / ADL / return to work at within 6 to 24 months; Pain at within 24 months

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Study	Gocen 2004[38]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=60)
Countries and setting	Conducted in Turkey; Setting: Department of Orthopaedics and Traumatology, Dokuz Eylul University, Izmir, Turkey
Line of therapy	Adjunctive to current care
Duration of study	Intervention + follow up: 8 weeks intervention and 2 years follow-up
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: People scheduled for THR with TPP and cementless acetabular component
Stratum	Overall
Subgroup analysis within study	Not applicable
Inclusion criteria	Scheduled for THR
Exclusion criteria	Physiotherapy for hip replacement before. Other chronic diseases or any other joint involvement necessitating treatment
Recruitment/selection of patients	From university hospital. Unclear if consecutive.
Age, gender and ethnicity	Age - Mean (SD): Intervention group: 47 (11), control group: 56 (14). Gender (M:F): 21/38. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Hip (THR).
Indirectness of population	No indirectness
Interventions	(n=30) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . Exercise routine, instructed to perform the exercises three times daily with 10 repetitions and were evaluated by a physiotherapist at two-week intervals. Education program including advice on movements that should be avoided, use of devices (such as crutches, elevated toilet seats, elevated beds and forceps to help dressing and undressing), posture, lifting and carrying, washing and bathing.. Duration Beginning eight weeks before the operation.. Concurrent medication/care: Both groups received the same postoperative and education program beginning from the day after the operation. Indirectness: No indirectness (n=30) Intervention 2: No formal preoperative rehabilitation or usual care - No formal preoperative rehabilitation or usual care class without individualised program. No preoperative exercises or education program was given to the patients in the control group. Duration Beginning eight weeks before the

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	operation.. Concurrent medication/care: Both groups received the same postoperative and education program beginning from the day after the operation. Indirectness: No indirectness
Funding	Funding not stated
RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: INDIVIDUALISED PREOPERATIVE REHABILITATION PROGRAM versus NO FORMAL PREOPERATIVE REHABILITATION Protocol outcome 1: Patient Reported Outcome Measures (PROMs) at within 6 to 24 months - Actual outcome: Change in Harris Hip Score at 2 years; Group 1: mean 54.53 (SD 16.39); n=29, Group 2: mean 50.96 (SD 15.27); n=30; Harris Hip Score 0-100 Top=High is good outcome Risk of bias: All domain - High, Selection - High, Blinding - Low, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: Intervention group younger: 47 compared to 56. ; Group 1 Number missing: 1, Reason: 1 due to no surgery; Group 2 Number missing: 0	
Protocol outcomes not reported by the study	Quality of life at within 6 to 24 months; Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Length of stay at time to event; Function / ADL / return to work at within 6 to 24 months; Pain at within 24 months

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Study	Huang 2012[45]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=243)
Countries and setting	Conducted in Taiwan; Setting: Tertiary medical centre in central Taiwan.
Line of therapy	Adjunctive to current care
Duration of study	Intervention time: 4 weeks
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: People scheduled to have unilateral primary TKA for advanced OA
Stratum	Overall
Subgroup analysis within study	Not applicable
Inclusion criteria	People scheduled to have unilateral primary TKA for advanced OA. Ability to follow our rehabilitation program and an interval of 4 weeks between enrolment and time until surgery.
Exclusion criteria	Patients with inflammatory arthritis or any medical condition in which a moderate level of exercise is contraindicated (e.g., heart failure or hypertension). People were not eligible if they were scheduled to have bilateral joint replacements.
Recruitment/selection of patients	From 2008 to 2010, eligible people from an orthopaedic department who were scheduled to undergo TKA.
Age, gender and ethnicity	Age - Mean (SD): 70 (7.3). Gender (M:F): 69/174. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Knee
Indirectness of population	No indirectness
Interventions	(n=126) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . Participants, in addition to following the protocol of the control group, also engaged in a preoperative rehabilitation education program beginning 2 to 4 weeks prior to admission. Preoperative program education: information on TKA hospitalization and discharge, post-TKA rehabilitation, safe transferring technique, device-using guide for crutches and canes, and fall prevention information. Exercise program: thigh muscle strength training.. Duration 4 weeks. Concurrent medication/care: Routine examinations including knee X-ray radiography, electrocardiography, and blood cell counts were arranged before admission for TKA. After surgery, all the participants participated in a standard rehabilitation program once a day for 40 min. The structure of this program was dependent on the patient's post-TKA functional status, which was determined by evaluations conducted by a physiotherapist. . Indirectness: No indirectness (n=117) Intervention 2: No formal preoperative rehabilitation or usual care - No formal preoperative

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	rehabilitation or usual care class without individualised program. During the time between enrolment in the study and hospitalization for TKA, usual leisure activities and exercises were not prohibited.. Duration 4 weeks. Concurrent medication/care: Routine examinations including knee X-ray radiography, electrocardiography, and blood cell counts were arranged before admission for TKA. After surgery, all the participants participated in a standard rehabilitation program once a day for 40 min. The structure of this program was dependent on the patient's post-TKA functional status, which was determined by evaluations conducted by a physiotherapist. After surgery, all the participants participated in a standard rehabilitation program once a day for 40 min. The structure of this program was dependent on the patient's post-TKA functional status, which was determined by evaluations conducted by a physiotherapist. Indirectness: No indirectness
Funding	Funding not stated
RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: INDIVIDUALISED PREOPERATIVE REHABILITATION PROGRAM versus NO FORMAL PREOPERATIVE REHABILITATION Protocol outcome 1: Length of stay at time to event - Actual outcome: Length of stay at Until discharge from hospital; Group 1: mean 7.12 days (SD 1.71); n=126, Group 2: mean 7.54 days (SD 1.2); n=117 Risk of bias: All domain - High, Selection - High, Blinding - Low, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Group 1 Number missing: ; Group 2 Number missing:	
Protocol outcomes not reported by the study	Quality of life at within 6 to 24 months; Patient Reported Outcome Measures (PROMs) at within 6 to 24 months; Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Function / ADL / return to work at within 6 to 24 months; Pain at within 24 months

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Study	Vukomanovic 2008[85]
Study type	RCT (Patient randomised; Parallel)
Number of studies (number of participants)	1 (n=45)
Countries and setting	Conducted in Serbia; Setting: Department of Orthopedics, Military Medical Academy, Clinic for Physical Medicine and Rehabilitation, Clinic for Traumatology and Orthopedics, Belgrade
Line of therapy	Adjunctive to current care
Duration of study	Intervention + follow up: 6 weeks intervention and 15 months follow-up
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: People scheduled to undergo primary total hip replacement
Stratum	Overall
Subgroup analysis within study	Not applicable:
Inclusion criteria	People scheduled to undergo primary total hip replacement, primary and secondary osteoarthritis, aged 70 and younger, gave informed consent to participate in the investigation, ability to walk up and down stairs, no need for using crutches while walking, no experience in walking with crutches, no coexisting morbidity such as a history of severe cardiovascular, respiratory, neuromuscular, rheumatic disease or mental confusion.
Exclusion criteria	Intraoperative (femoral or acetabular fracture) or postoperative complications (postoperative disorientation, anaemia, circulatory collapse, orthostatic hypotension, chest pain, sustained hypertension, deep venous thrombosis, pulmonary embolism, hip dislocation) which compromised or delayed the beginning of physical therapy after the operation.
Age, gender and ethnicity	Age - Mean (SD): Intervention group: 60 (11), control group: 56 (18). Gender (M:F): Define. Ethnicity: Not detailed
Further population details	1. Site of joint replacement: Hip (THA).
Indirectness of population	No indirectness
Interventions	(n=23) Intervention 1: Individualised preoperative rehabilitation programmes with specific aims - Individualised preoperative rehabilitation programmes with specific aims, involving multiple sessions, from surgery being offered: prescribed and supervised exercises, advice and equipment by a member of the rehabilitation team . Short-term intensive preoperative preparation, which consisted of education and elements of physical therapy. Information about the operation, caution measures and rehabilitation after the arthroplasty through conversation with the physiatrist and a brochure. A physiotherapist instructed the person how to perform exercises and basic activities from the postoperative rehabilitation program, such as bed mobility, getting out and in bed, standing and walking with crutches, use of toilet, sitting on chair, walking up and down stairs with aids. The study group had one appointment with the physiatrist and two practical classes with a physiotherapist.. Duration 6 weeks until surgery. Concurrent medication/care: Both treatment groups had the same program of rehabilitation after the arthroplasty. The program of rehabilitation

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	for patients started on the first day after the operation.. Indirectness: No indirectness (n=22) Intervention 2: No formal preoperative rehabilitation or usual care - No formal preoperative rehabilitation or usual care class without individualised program. Group did not receive preoperative education and physical therapy. Duration 6 weeks until surgery. Concurrent medication/care: Both treatment groups had the same program of rehabilitation after the arthroplasty. The program of rehabilitation for patients started on the first day after the operation.. Indirectness: No indirectness
Funding	Funding not stated
RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: INDIVIDUALISED PREOPERATIVE REHABILITATION PROGRAM versus USUAL CARE CLASS WITHOUT INDIVIDUALISED PROGRAM Protocol outcome 1: Patient Reported Outcome Measures (PROMs) at within 6 to 24 months - Actual outcome: Oxford Hip Score at 15 months; Group 1: mean 17.06 (SD 6.1); n=18, Group 2: mean 17.59 (SD 7.84); n=18; Oxford Hip Score 0-48 Top=High is good outcome Risk of bias: All domain - Very high, Selection - High, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: Oxford hip score varies between groups. Study suggests a higher score indicates worse function though this is non-standard. Oxford score normally indicates better function through higher scores. ; Group 1 Number missing: 5, Reason: 3 intraoperative and postoperative complications, 2 lost to follow-up; Group 2 Number missing: 4, Reason: 2 intraoperative and postoperative complications, 2 lost to follow-up Protocol outcome 2: Length of stay at time to event - Actual outcome: Length of hospital stay at Time until discharge; Group 1: mean 9.8 days (SD 2.4); n=20, Group 2: mean 10.2 days (SD 1.7); n=20 Risk of bias: All domain - High, Selection - High, Blinding - Low, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness ; Baseline details: Oxford hip score varies between groups. Study suggests a higher score indicates worse function though this is non-standard. Oxford score normally indicates better function through higher scores. ; Group 1 Number missing: 5, Reason: 3 intraoperative and postoperative complications, 2 lost to follow-up; Group 2 Number missing: 4, Reason: 2 intraoperative and postoperative complications, 2 lost to follow-up	
Protocol outcomes not reported by the study	Quality of life at within 6 to 24 months; Revision of joint replacement at time to event; Depression at within 24 months; Disability at within 6 to 24 months; Hospital readmissions at within 90 days; Muscle atrophy at within 24 months; Function / ADL / return to work at within 6 to 24 months; Pain at within 24 months

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Appendix E: Forest plots

E.1 Individualised preoperative rehabilitation programmes versus usual care

Figure 2: Quality of life: SF36 MCS

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Beaupre 2004	56	9	51	58	7	58	-2.00 [-5.06, 1.06]

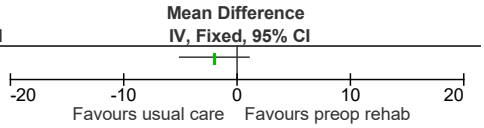

Figure 3: Quality of life: SF36 PCS

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Beaupre 2004	38	8	51	41	10	58	-3.00 [-6.38, 0.38]

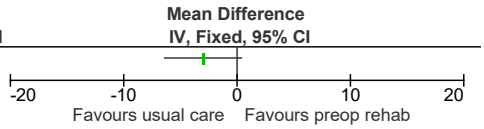

Figure 4: PROMs: change in Harris Hip Score

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Gocen 2004	54.53	16.39	29	50.96	15.27	30	3.57 [-4.52, 11.66]

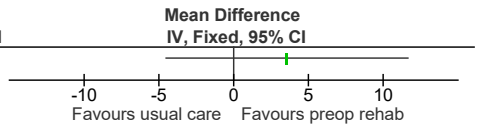

Figure 5: PROMs: WOMAC function

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Beaupre 2004	77	14	51	77	16	58	0.00 [-5.63, 5.63]

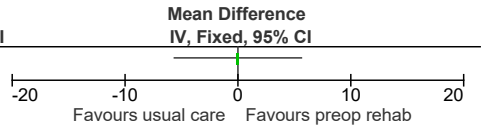

Figure 6: PROMs: WOMAC pain

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Beaupre 2004	82	13	51	80	16	58	2.00 [-3.45, 7.45]

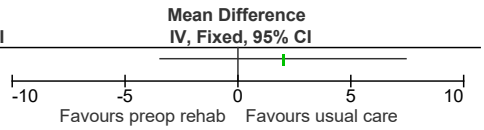

Figure 7: PROMs: WOMAC stiffness

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Beaupre 2004	67	18	51	71	21	58	-4.00 [-11.32, 3.32]

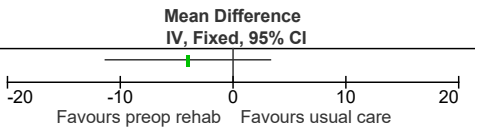

Figure 8: PROMs: Oxford Hip Score

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Vukomanovic 2008	17.06	6.1	18	17.59	7.84	18	-0.53 [-5.12, 4.06]

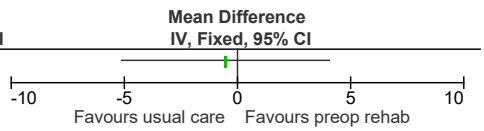

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Figure 9: Length of stay

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Beaupre 2004	6.7	2.2	55	7.3	2.5	60	26.4%	-0.60 [-1.46, 0.26]
Crowe 2003	6.55	4.2	65	10.5	4.2	68	21.3%	-3.95 [-5.38, -2.52]
Huang 2012	7.12	1.71	126	7.54	1.2	117	29.7%	-0.42 [-0.79, -0.05]
Vukomanovic 2008	9.8	2.4	20	10.2	1.7	20	22.6%	-0.40 [-1.69, 0.89]
Total (95% CI)			**266**			**265**	**100.0%**	**-1.22 [-2.42, -0.01]**

Heterogeneity: Tau² = 1.24; Chi² = 22.13, df = 3 (P < 0.0001); I² = 86%
Test for overall effect: Z = 1.98 (P = 0.05)

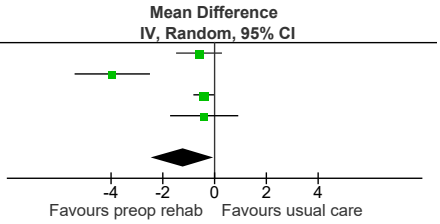


Figure 10: Function (AIMS score)

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Mean Difference IV, Fixed, 95% CI
Berge 2004	42.89	8.44	18	49.12	8.44	15	-6.23 [-12.01, -0.45]

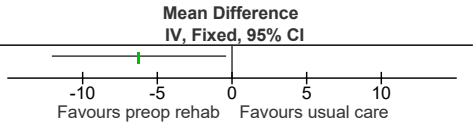
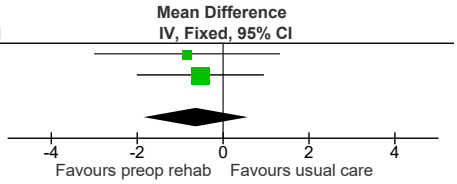


Figure 11: Pain (VAS or NRS)

Study or Subgroup	Preoperative rehab Mean	SD	Total	Usual care Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Berge 2004	2.36	3.09	18	3.2	3.17	15	31.7%	-0.84 [-2.99, 1.31]
Ferrara 2008	-6.8	1.84	11	-6.27	1.73	12	68.3%	-0.53 [-1.99, 0.93]
Total (95% CI)			**29**			**27**	**100.0%**	**-0.63 [-1.84, 0.58]**

Heterogeneity: Chi² = 0.05, df = 1 (P = 0.82); I² = 0%
Test for overall effect: Z = 1.02 (P = 0.31)



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Appendix F: GRADE tables

Table 10: Clinical evidence profile: Individualised preoperative rehabilitation programmes versus usual care

Quality assessment							No of patients		Effect		Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Individualised preoperative rehabilitation	Control	Relative (95% CI)	Absolute		
Quality of life: SF36 PCS (follow-up 1 years; range of scores: 0-100; Better indicated by higher values)												
1	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	51	58	-	MD 2 lower (5.06 to 1.06 lower)	⊕⊕OO LOW	CRITICAL
Quality of life: SF36 MCS (follow-up 1 years; range of scores: 0-100; Better indicated by higher values)												
1	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	51	58	-	MD 3 lower (6.38 lower to 0.38 higher)	⊕⊕OO LOW	CRITICAL
PROMs: change in Harris Hip Score (follow-up 2 years; range of scores: 0-100; Better indicated by higher values)												
1	randomised trials	very serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	29	30	-	MD 3.57 higher (4.52 lower to 11.66 higher)	⊕OOO VERY LOW	CRITICAL
PROMs: WOMAC function (follow-up mean 1 years; range of scores: 0-100; Better indicated by higher values)												
1	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	51	58	-	MD 0 higher (5.63 lower to 5.63 higher)	⊕⊕⊕O MODERATE	CRITICAL
PROMs: WOMAC pain (follow-up mean 1 years; range of scores: 0-100; Better indicated by higher values)												
1	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	51	58	-	MD 2 higher (3.45 lower to 7.45 higher)	⊕⊕OO LOW	CRITICAL

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PROMs: WOMAC stiffness (follow-up mean 1 years; range of scores: 0-100; Better indicated by higher values)												
1	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	51	58	-	MD 4 lower (11.32 lower to 3.32 higher)	⊕⊕OO LOW	CRITICAL
PROMs: Oxford Hip Score (follow-up mean 15 months; range of scores: 0-48; Better indicated by higher values)												
1	randomised trials	very serious[1]	no serious inconsistency	no serious indirectness	very serious[2]	none	18	18	-	MD 0.53 lower (5.12 lower to 4.06 higher)	⊕OOO VERY LOW	CRITICAL
Length of stay (follow-up N/A; Better indicated by lower values)												
4	randomised trials	serious[1]	very serious[3]	no serious indirectness	serious[2]	none	266	265	-	MD 1.22 lower (2.42 to 0.01 lower))	⊕OOO VERY LOW	IMPORTANT
Function (AIMS score) (follow-up median 8 months; range of scores: 0-90; Better indicated by lower values)												
1	randomised trials	very serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	18	15	-	MD 6.23 lower (12.01 to 0.45 lower)	⊕OOO VERY LOW	IMPORTANT
Pain (NRS or change in VAS) (follow-up 3-8 months; range of scores: 0-10; Better indicated by lower values)												
2	randomised trials	very serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	29	27	-	MD 0.63 lower (1.84 lower to 0.58 higher)	⊕OOO VERY LOW	IMPORTANT
Pain (Change in VAS) (follow-up 3 months; range of scores: 0-10; Better indicated by lower values)												
1	randomised trials	very serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	11	12	-	MD 0.53 lower (1.99 lower to 0.93 higher)	⊕OOO VERY LOW	IMPORTANT

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Appendix G: Health economic evidence selection

Figure 12: Flow chart of health economic study selection for the guideline

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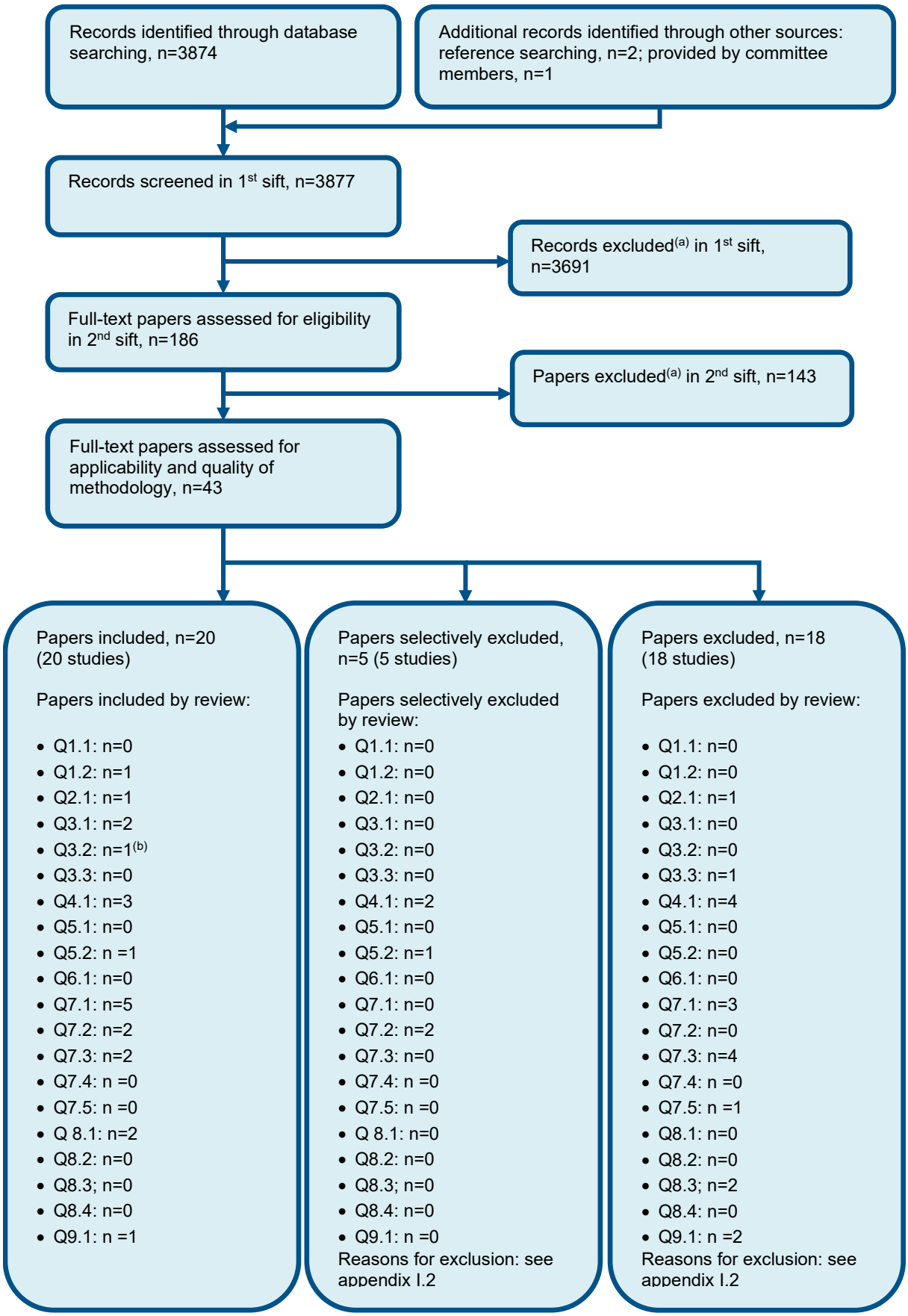

a) Non-relevant population, intervention, comparison, design or setting; non-English language
b) One study was applicable to both Q3.1 and Q3.2

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Appendix H: Health economic evidence tables

Study	Beaupre 2004[5]			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: Cost-consequences analysis **Study design:** Randomised controlled trial – Beaupre 2004[5] **Perspective:** Canadian health service **Time horizon/Follow-up** 12 months **Discounting:** NR	**Population:** People on a waiting list for total knee replacement Mean age: 67 **Intervention 1:** Advice and equipment: crutch walking, bed mobility and transfers, postoperative ROM routine. Exercise: designed to improve knee mobility and strength. 12 sessions over 4 weeks. **Intervention 2:** Continued regular activities until surgery.	**Total costs (mean per patient):** 1: 743, 2: 745 Incremental (2−1): 1.63 (95% CI: NR; p=0.99) **Currency & cost year:** 1997-8 Canadian dollars (presented here as 1998 UK pounds[(a)]) **Cost components incorporated:** Programme costs, hospital costs including transfer and readmission, homecare and community rehabilitation.	**SF-36 PCS (mean change at 12 months per patient):** 1: +12, 2: +9 Incremental (2−1): -3 (95% CI: NR; p=NR) **SF-36 MCS (mean change at 12 months per patient):** 1: +3 2: +5 Incremental (2−1): +2 (95% CI: NR; p=NR) **Total hospital length of stay** 1: 11.7, 2: 10.2 Incremental (2−1): -1.5 (95% CI: NR; p=0.10)	Indeterminate **Analysis of uncertainty:** There were no sensitivity analyses conducted
Data sources				
Health outcomes: This is an original trial. **Cost sources:** Resource use from the trial. Unit costs were standard daily or hourly costs for the service (Capital Health).				
Comments Other outcomes reported were WOMAC, Knee ROM and strength scores				
Source of funding: Alberta Heritage Foundation for Medical Research and Capital Health. **Applicability issues:** Canadian setting; no QALYs **Limitations:** single underpowered trial; costs are from 1997/8. Discount rate was not reported.				
Overall applicability:[(b)] Partially applicable **Overall quality:**[(c)] Potentially serious limitations				

Abbreviations: CCA: cost–consequences analysis; 95% CI: 95% confidence interval; MCS=Mental component score; NR: not reported; PCS=Physical component score; QALYs: quality-adjusted life years; ROM=Range of motions
(a) Converted using 1998 purchasing power parities[65]
(b) Directly applicable / Partially applicable / Not applicable
(c) Minor limitations / Potentially serious limitations / Very serious limitations

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Appendix I: Excluded studies

I.1 Excluded clinical studies

Table 11: Studies excluded from the clinical review

Study	Exclusion reason
Alghadir 2016[1]	Treatment groups do not vary in terms of advice offered
Aoki 2009[2]	Treatment groups do not vary in terms of advice offered
Aydin 2015[3]	Did not include studies of people scheduled for shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Aytekin 2019[4]	Controlled trial was not randomised
Biau 2015[7]	Intervention does not include exercises
Bitterli 2011[8]	Treatment groups do not vary in terms of advice offered
Blasco 2017[9]	Treatment groups do not vary in terms of advice offered
Borjesson 1996[10]	Not review population
Brown 2012[12]	Treatment groups do not vary in terms of advice offered
Brown 2014[11]	Treatment groups do not vary in terms of advice offered
Butler 1996[13]	Incorrect intervention: not individualised
Cabilan 2015[14]	Did not include studies of people scheduled for shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Cabilan 2016[15]	Incorrect population. Relevant includes checked for this review.
Calatayud 2017[16]	Treatment groups do not vary in terms of advice offered
Cavill 2016[17]	Intervention extended to the postoperative period
Chen 2018[18]	Did not include studies of people scheduled for hip or shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Chesham 2017[19]	Did not include studies of people scheduled for hip or shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Clode-baker 1997[20]	Treatment groups do not vary in terms of exercise offered
Cooil 1997[21]	Treatment groups do not vary in terms of advice offered
Cooke 2016[22]	Treatment groups do not vary in terms of exercise offered
Czyzewska 2014[24]	Incorrect study design
Daltroy 1998[26]	Intervention does not include exercises
D'lima 1996[25]	Treatment groups do not vary in terms of advice offered
Doering 2001[28]	Not English language
Doiron-cadrin 2016[29]	Protocol for an RCT
Evgeniadis 2008[31]	Treatment groups do not vary in terms of advice offered
Fernandes 2017[32]	Treatment groups do not vary in terms of advice offered
Gammon 1996[34]	Intervention does not include exercises
Gilbey 2003[35]	Treatment groups do not vary in terms of advice offered
Gill 2013[36]	Did not include studies of people scheduled for shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Giraudet-le quintrec 2003[37]	Intervention does not include exercises

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Study	Exclusion reason
Goh 2015[39]	Incorrect study design
Gstoettner 2011[40]	Treatment groups do not vary in terms of advice offered
Hayes 2014[41]	Unable to obtain
Hermann 2016[42]	Treatment groups do not vary in terms of advice offered
Hoogeboom 2010[43]	Treatment groups do not vary in terms of advice offered
Hopman-rock 2000[44]	Not review population
Huber 2013[46]	Inappropriate comparison
Huber 2015[47]	Inappropriate comparison
Jepson 2016[48]	Intervention extended to the postoperative period
Johansson 2007[49]	Intervention does not include exercises
Kearney 2011[50]	Incorrect study design
Kwok 2015[51]	Did not include studies of people scheduled for hip or shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Leal-blanquet 2013[52]	Incorrect interventions
Lucas 2013a	Incorrect study design
Lucas 2013b	Incorrect study design
Majid 2015[53]	Unable to obtain
Mancuso 2008[54]	Intervention does not include exercises
Mat eil ismail 2016[55]	Treatment groups do not vary in terms of advice offered
Matassi 2014[56]	Treatment groups do not vary in terms of advice offered
Mcdonald 2014[57]	Did not include studies of people scheduled for shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Mcgregor 2004[58]	Intervention does not include exercises
Mckay 2012[59]	Treatment groups do not vary in terms of advice offered
Memtsoudis 2014[60]	Incorrect interventions
Mitchell 2005[61]	Variation between treatment groups in postoperative care
Moyer 2017[62]	Did not include studies of people scheduled for shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Oosting 2012[64]	Treatment groups do not vary in terms of exercise offered
Osborne 2006[66]	Not review population
Peer 2017[67]	Did not include studies of people scheduled for hip or shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Pour 2007[68]	Interventions post surgery varied between treatment groups
Rivard 2003[69]	Intervention does not include exercises
Rodgers 1998[70]	Treatment groups do not vary in terms of advice offered
Rooks 2006[71]	Treatment groups do not vary in terms of advice offered
Santavirta 1994[72]	Treatment groups do not vary in terms of advice offered
Saw 2016[73]	Treatment groups do not vary in terms of advice offered
Siggeirsdottir 2005[74]	Interventions post surgery varied between treatment groups
Sjoling 2003[75]	Incorrect interventions
Skoffer 2016[76]	Treatment groups do not vary in terms of advice offered
Soeters 2018[77]	Intervention does not include exercises
Swank 2011[78]	Treatment groups do not vary in terms of advice offered

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Study	Exclusion reason
Thingstad 2016[79]	Variation between treatment groups in postoperative care
Topp 2009[80]	Treatment groups do not vary in terms of advice offered
Tungtrongjit 2012[81]	Treatment groups do not vary in terms of advice offered
Van leeuwen 2014[82]	Treatment groups do not vary in terms of advice offered
Villadsen 2014[84]	Treatment groups do not vary in terms of advice offered
Villadsen 2016[83]	Did not include studies of people scheduled for shoulder joint replacement. Included studies were checked for inclusion in this evidence review.
Walls 2010[86]	Treatment groups do not vary in terms of advice offered
Wang 2002[87]	Treatment groups do not vary in terms of advice offered
Wang 2016[88]	Interventions differ from this review. Included studies checked for inclusion in this review.
Weaver 2003[89]	Variation between treatment groups in postoperative care
Weidenhielm 1993[90]	Treatment groups do not vary in terms of advice offered
Wijgman 1994[91]	Not English language
Williamson 2007[92]	Treatment groups do not vary in terms of advice offered
Wilson 2016[93]	Intervention does not include exercises
Yin 2015[94]	Not review population
Zeng 2015[95]	Treatment groups do not vary in terms of advice offered

I.2 Excluded health economic studies

Table 12: Studies excluded from the health economics review

Study	Exclusion reason
Huang 2012[45]	Key cost component was not included.

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Appendix J: Research recommendations

J.1 Preoperative rehabilitation

Research Question: What is the clinical and cost-effectiveness of a pre-operative rehabilitation given at least 2 months before hip, knee or shoulder replacement?

Why is this important:

People prior to hip, knee or shoulder replacement frequently present with a history of chronic joint pain, fear of movement and reduced physical function and independence with personal or extended activities of daily living. Following joint replacement, rehabilitation is aimed to address these to facilitate recovery. However, patient recovery may be enhanced both in speed and in outcome, through the provision of pre-operative rehabilitation interventions. These are aimed to increase physiological capability such as exercise tolerance and weight loss, pain management strategies and psychological readiness for surgery and subsequent recovery. Preoperative assessment of ADL performance and provision of advice and interventions aim to maintain and maximise function in the lead up to surgery. The current evidence-base on these interventions is limited in quality, with interventions largely assessed on exercise and education provision only. Future research in this area would provide clinicians and patients with a better understanding on what pre-operative interventions are indicated for improved post-operative outcomes, and which patients may be best directed to such interventions.

Criteria for selecting high-priority research recommendations:

PICO question	Population: Adults listed 2 months prior to a hip, knee or shoulder replacement. Intervention: Each person receives an individualised preoperative rehabilitation programme tailored to their clinical presentation. This programme could include: exercise interventions, psychological assessment with counselling or cognitive therapy, weight control, pain medication review or prescription, provision of equipment and assistive technologies, education on pre- and post-operative health promotion and physical activity advice. It could be delivered individually, or using the guidance of the individual programme, in a group-setting (e.g. Joint School). Interventions should be of sufficient duration to be able to provide physiological benefit (i.e. strength, range of motion, cardiovascular). Comparison: Usual care which does not involve individualised pre-operative rehabilitation interventions. Outcome(s): Pain, function, health related quality of life, adverse events, health economic measures (direct and indirect costs)
Importance to patients or the population	If patients can modify factors associated with poor outcome and post-operative complications such as excessive weight, smoking and low physical capability such as mobility and joint strength and have greater understanding on the post-operative recovery phase through cognitive support and education, their outcome may be improved. Furthermore, with reduced post-operative complications and increased readiness for recovery, reduced length of stay or requirement for ongoing rehabilitation, this may translate to reduced costs incurred on NHS services, thereby providing resources to other services for wider patient care.
Relevance to NICE guidance	A recommendation was made to offer pre-operative rehabilitation for people listed for hip or knee replacement surgery. No recommendation has been made for people undergoing shoulder replacement surgery. Due to the limited quantity and quality of the current evidence. Further

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	research on these may enable recommendations on their use to be included in future updates of the guideline.
Relevance to the NHS	Improved pre-operative rehabilitation capabilities and readiness for recovery could improve patient's health related quality of life and clinical outcomes. Improving these could reduce the risk of post-operative complications and prolonged rehabilitation needs. This may therefore reduce the NHS needs patients incur both in primary and secondary care sectors during the recovery phases following joint replacement surgery.
National priorities	N/A
Current evidence base	High quality evidence for pre-operative rehabilitation interventions for people listed for hip, knee or shoulder replacement surgery is lacking.
Equality	None
Study design	Randomised controlled trial comparing pre-operative rehabilitation in addition to conventional pre-operative consent and medical assessment compared to conventional pre-operative consent and medical assessment alone. Participants randomised to the pre-operative rehabilitation intervention should be provided with this intervention a minimum of 2 months prior to surgery to confer physiological benefits to exercise.
Feasibility	This has been designed to reflect current clinical practice where a 2-month interval between listing and surgery is feasible. A longer duration may not be feasibility against waiting list targets. Funding could provide a challenge as it would be unlikely that funding could be gained from commercial funders given the intervention is non-pharmacological or a device. Recruitment for this population is feasible given the numbers of joint replacements conducted each year. However, assessment of compliance to the intervention over the 2-month proposed intervention period could be challenging for individuals with chronic pain and therefore should be designed to be flexible to account for an individual's specific care needs..
Other comments	The potential clinical and cost-effectiveness benefits which this intervention may provide, for a population which is not insignificant in the NHS from a patient-number perspective, means this is a research importance.
Importance	Moderate: the research is of interest and will fill existing evidence gaps.

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