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SYSTEMATIC REVIEW

Effects of home-based prehabilitation on pre- and postoperative outcomes following total hip and knee arthroplasty

A SYSTEMATIC REVIEW AND META-ANALYSIS

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Aims

The aim of this study was to determine the effectiveness of home-based prehabilitation on pre- and postoperative outcomes in participants awaiting total knee (TKA) and hip arthroplasty (THA).

Methods

A systematic review with meta-analysis of randomized controlled trials (RCTs) of prehabilitation interventions for TKA and THA. MEDLINE, CINAHL, ProQuest, PubMed, Cochrane Library, and Google Scholar databases were searched from inception to October 2022. Evidence was assessed by the PEDro scale and the Cochrane risk-of-bias (ROB2) tool.

Results

A total of 22 RCTs (1,601 patients) were identified with good overall quality and low risk of bias. Prehabilitation significantly improved pain prior to TKA (mean difference (MD) -1.02: p = 0.001), with non-significant improvements for function before (MD -0.48; p = 0.06) and after TKA (MD -0.69; p = 0.25). Small preoperative improvements were observed for pain (MD -0.02; p = 0.87) and function (MD -0.18; p = 0.16) prior to THA, but no post THA effect was found for pain (MD 0.19; p = 0.44) and function (MD 0.14; p = 0.68). A trend favouring usual care for improving quality of life (QoL) prior to TKA (MD 0.61; p = 0.34), but no effect on QoL prior (MD 0.03; p = 0.87) or post THA (MD -0.05; p = 0.83) was found. Prehabilitation significantly reduced hospital length of stay (LOS) for TKA (MD -0.43 days; p < 0.001) but not for THA (MD, -0.24; p = 0.12). Compliance was only reported in 11 studies and was excellent with a mean value of 90.5% (SD 6.82).

Conclusion

Prehabilitation interventions improve pain and function prior to TKA and THA and reduce hospital LOS, though it is unclear if these effects enhance outcomes postoperatively.

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Keywords: Prehabilitation, Exercise, Hip, Knee, Arthroplasty, Home-based

Introduction

Patients awaiting arthroplasty suffer considerable pain and functional disability, and prolonged waiting times contribute to poorer quality of life (QoL).[1,2] A recent study assessing the QoL of patients with osteoarthritis suggested that 22% and 45% of patients awaiting total knee (TKA) and hip arthroplasty (THA), respectively, are in a health state “worse than death”.[3] Although specific comorbidities contribute to this, pain and functional limitations appear to be key determinants.[4] Comorbidities may have a larger impact than age alone on postoperative outcomes, which may be associated with increased complications, longer hospital stays, and readmissions in older patients awaiting TKA and THA.[5-7]

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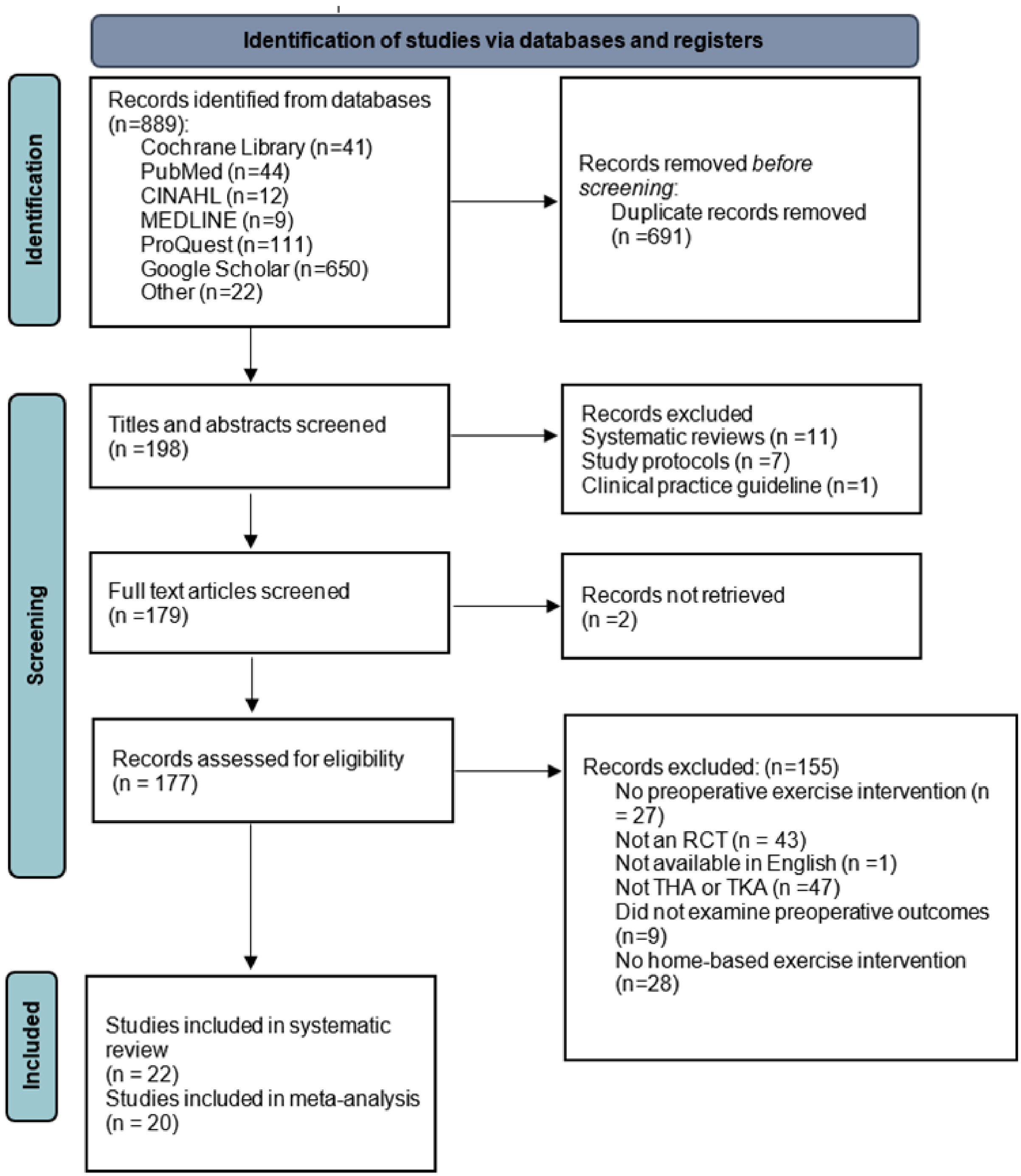

Fig. 1

Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of study selection process. RCT, randomized controlled trial; THA, total hip arthroplasty; TKA, total knee arthroplasty.

Poor preoperative physical function and mental health are associated with inferior postoperative functional recovery.[8–10] Outcome trajectories have been linked to several factors. Poor responders present at lower baseline physical health status with marked functional limitations, and seem to have preoperative expectations of pain and reduced coping ability.[11] Good responders seem to have a combination of enhanced QoL factors such as good clinical, psychosocial, and mental health.[11] As such, the long-term effectiveness of surgery and rehabilitation is reduced for patients with poorer preoperative status in comparison to those with better preoperative physical function and mental health.[12]

Table I. Summary of included trials. Prehabilitation interventions compared with usual care for total hip and total knee arthroplasty.

Study; type	Sample size, n*	Mean age, yrs (SD)*	Female, %*	Joint	All outcome measures†	Time to surgery	Preoperative intervention	Follow-up	Compliance
An et al (2021); RCT	18/17/18	71.1 (3.3)/70.05 (2.41)/70.38 (2.59)	100/100/100	Knee	**WOMAC pain, function**, and total, **QS strength with dynamometer**, TUG, knee flexion ROM, PPT	6 mths	Remote telerehabilitation group: Warm-up, mobility, flexibility, strength and balance training. 2× / day, 5 days/wk for 3 wks. Preoperative patient education group: non-supervised exercise 2× /day, 5 days/wk for 3 wks	Preop, postop at 6 wks	90% exercise prehab; 85% education
Aoki et al (2009); RCT	17/19	72.3 (5.2)/74.4 (6.4)	100/100	Knee	**Pain: VAS (during gait)**, gait speed (m/min), knee flexion ROM	3 mths	Home-based knee flexibility exercises daily for 11 to 12 wks	Preop only (admission day)	93.1% of days and 91% of sessions completed
Borjesson et al (1996); RCT	34/34	64 (4)/64 (5)	50/50	Knee	**Pain during walking out of 10**, passive ROM, step up and down, QS, free walking speed (m/sec), step frequency (steps/sec), stride length, single stance phase (% gait cycle) of each leg	N/R	Strengthening, stretching and aerobic exercise; unsupervised home exercise 2× /wk; supervised classes 3×/ wk for 5 wks	Preop (12-wk intervention)	N/R
Bruce-Brand et al (2012); prospective RCT	10/10/6	63.9 (5.8)/63.4 (5.9)/65.2 (3.1)	66/66/50	Knee	25 m walk test, repeated CRT, SCT, **WOMAC function, pain,** and stiffness, SF-36, QS strength and QS cross-sectional area	6 mths	Intervention 1: Home-based resistance training 3× /wk for 6 wks Intervention 2: Unsupervised NMES session of the affected QFM, 5 days/wk for 6 wks	Preop (8-wk intervention), post-intervention at 6 wks and 14 wks	70% over 18 mths; NMES 91%; RT 83%
Ho et al (2022); prospective RCT	35/35	73.5 (5.3)/74.4 (5.4)	71/88	Knee	**VAS pain**, STAI, **WOMAC function**, AKS	N/R	Integrated education programme: verbal preop education, prehabilitation, multidisciplinary personal rehab during hospital stay, supervised home-based exercise after discharge	Preop (admission day), discharge day, postop at 2, 6, and 13 wks	N/R
Crotty et al (2009); RCT	75/77	68.1 (10.6)/67.0 (11.0)	60/60	Hip and knee	**AQoL**, CES-D, **WOMAC pain, function** and stiffness, BMQ, HeiQ	N/R	Self-management action designed for personal home-based and community-based exercise goals; monthly telephone call by a support volunteer; encouraged to attend 'Moving towards wellness' course; encouraged to attend 2× arthroplasty education sessions	Preop (6-mth intervention); surgery may have occurred	N/R
Doiron-Cadrin et al (2020); pilot RCT	11/12/11	69.9 (9.1)/61.3 (8.1)/66.7 (9.2)	64/83/73	Hip and knee	LEFS, **WOMAC pain, function**, and stiffness; SF-36, PCS, MCS, TUG, SPW, SCT	N/R	Two supervised physiotherapy sessions/ wk through telecommunication; repeat the same exercises 5 days/wk at home without supervision and keep a logbook	Preop only (12-wk intervention)	Telerehabilitation 77%; in-person 80%
Gilbey et al (2003); prospective RCT	37/31	66.73 (10.19)/63.29 (12.01)	57/68	Hip	**WOMAC pain, function**, stiffness, and total patient satisfaction questionnaire	8 wks	Aerobic, strength and hydrotherapy sessions. 2× clinic and 2× home sessions, 1 hr/wk for 8 wks	1 wk preop, postop at 3, 12, and 24 wks	Scheduled, 97%; home-based, 95%
Gocen et al (2004); prospective RCT	29/30	46.93 (11.48)/55.50 (14.44)	45/27	Hip	**VAS pain, HHS**, ROM hip abduction	N/R	Home exercise and education 3×/day for 8 wks	Preop (1 day before surgery), at discharge, postop at 3 and 24 mths	N/R
Hoogeboom et al (2010); pilot RCT	10/11	77.3 (3)/75.0 (5)	70/64	Hip	**HOOS pain, function**, symptoms, and QOL. LAPAQ, PSC, **VAS pain**, 6MWT, TUG, CRT; PWC-170, HGS	3 wks	Supervised exercise programme and home exercise, 2×/wk for 3 to 6 wks	Preop, postop (LOS, complications)	91%
Huang et al (2012); prospective RCT	126/117	69.8 (7.2)/70.5 (7.4)	68.8/73.5	Knee	Knee ROM, **VAS pain, LOS**	4 wks	Education and home exercise strengthening for 4 wks	Preop, postop 5 days until discharge (LOS, complications)	N/R
Matassi et al (2012); prospective RCT	61/61	66 6 (7.2)/67 (7.7)	54/43	Knee	Days before reaching 90° of knee flexion, knee ROM, **KSS, LOS**	N/R	Exercise instruction plus unsupervised exercise, 5 days/wk for 6 wks	Preop, postop at 6 wks, 6 mths, 12 mths	N/R
Mikkelsen et al (2014); RCT	32/30	64.8 (8)/65.1 (10)	44/40	Hip	Leg extension power: The Nottingham Power Rig, max walking speed (20 m walk test), CRT, SCT, HHD, **HOOS pain, function**, and ADL	10 wks	I: home-based exercise 5 days/wk and progressive resistance training 2 days/wk C: home-based exercise 7 days/wk	Preop (10-wk intervention), 6 and 12 mths postop	85%
Nunez et al (2006); RCT	51/49	72.6 (6.2)/69.5 (6.8)	76/65	Knee	HRQL, **WOMAC pain, function**, and stiffness, SF-36, number/cost of visits to general physician	< 6 mths	2 individual sessions and 2 group sessions and education followed by daily home exercise	Preop (3-mth intervention), F/U 9 mths	N/R

Continued

Table I. Continued

Study; type	Sample size, n*	Mean age, yrs (SD)*	Female, %*	Joint	All outcome measures†	Time to surgery	Preoperative intervention	Follow-up	Compliance
Oosting et al (2012); pilot RCT	15/15	76.9 (6.3)/75.0 (6.3)	93/67	Hip	PSC, CRT, 6MWT, TUG, VAS Pain, **HOOS Pain, function** and ADL, function in sport and recreation, hip-related QoL, LAPAQ	> 3 wks	Supervised home exercise, 30 min, 2×/wk and 4 unsupervised exercise sessions for 3 to 6 wks	Preop (6-wk intervention), postop complication rate, LOS, or functional recovery	99%
Rittharomya et al (2020); RCT	48/44	Young-old (60-69) 26, Middle-aged old (70-79) 22/ Young old (60-69) 23, Middle-aged old (70-79) 21	89/88	Knee	SEEQ, **NPRS**, HHD, ROM (goniometer), TUG, Mini-OAKHQOL	> 3 mths	Health information, quadriceps exercise, and monitoring through telephone or LINE application; quadriceps training exercise demonstrated and practised; encouraged home-based quadriceps exercise 60 to 100 times/day 5×/ wk.	Preop only (12-wk intervention)	N/R
Soeters et al (2018); RCT	63/63	61 (9)/62 (8)	56/71	Hip and knee	**WOMAC pain, function**, stiffness, and total, **LOS**	N/R	One supervised demonstration: precautions, exercises, bed mobility, ambulation, stairs negotiation; provided access to microsite with videos, pictures and information about exercises, transfers, ambulation and ADL	Preop online intervention (4 to 6 wks), postop F/U at 4 to 6 wks (LOS, function)	Preop 96%; postop 76%
Swank et al (2011); RCT	36/35	63. (7.3)/62.6 (7.6)	67/63	Knee	**VAS pain**, 6MWT, STS, Ascend time for the first and second second flight of stairs (s), Peak torque extension/flexion with surgical/non-surgical leg	N/R	Home-based exercise 2×/ week and supervised exercise 1×/wk for 4 to 8 wks	Preop intervention only	90%
Topp et al (2009); RCT	26/28	64.1 (7.05)/63.6 (6.68)	73/64	Knee	**VAS pain**, STS, up/ down stairs, 6MWT, QS	5 mths	Resistance, flexibility and step training, 1 supervised and 2 home sessions, 3×/wk	Preop 4 wk, assessment (5 mth intervention), postop F/U at 4 and 12 wks	N/R
Tungtrongjit et al (2012); RCT	30/30	63 (7.6)/65.9 (7.2)	86.7/80.0	Knee	**VAS pain**, ROM, QS, **Modified WOMAC: pain, function**, and stiffness	N/R	Quadriceps strengthening home programme, 3×/day for 3 wks	Preop intervention until surgery; postop F/U 1, 3, and 6 mths	N/R
Walls et al (2010); pilot RCT	9/5	64.4 (8.)0/63.2 (11.4)	67/80	Knee	**WOMAC pain, function**, stiffness, SCT, CRT. Timed walk (25 m), QS, SF-36, PCS, MCS, **LOS**, discharge destination	N/R	Home-based NMES and resistance exercise, 20 min/day for 5 days/wk for 8 wks	Preop 6-wk intervention, postop F/U 6 and 12 wks	99%
Weidenhielm et al (1993); RCT	20/20	64 (4)/63 (5)	55/45	Knee	**Pain: 4-point scale and 10-point scale during walk**, walking speed (self-selected), max walk speed, knee ROM, QS	3 mths	Strengthening, stretching and aerobic exercise. Supervised group sessions 3×/wk unsupervised home exercise daily	Preop intervention for 3 wks; postop F/U 3 mths	N/R

*Data presented as I1/(I2)/C.
†Applicable outcome measures highlighted in bold.
ADL, activities of daily living; AIMS, Arthritis Impact Measurement Scale; AKS, American Knee Society score; AQoL, Assessment of Quality of Life; BMQ, Beliefs About Medicines questionnaire; C, control group; CES-D, Centre for Epidemiologic Studies Depression scale; CRT, chair rise time; F/U, follow-up; HAD, Hospital Anxiety and Depression score; HADSA, Hospital Anxiety and Depression score (anxiety subdomain); HeiQ, Health Education Impact questionnaire; HGS, hand grip strength; HHD, hand-held dynamometry; HHS, Harris Hip Score; HOOS, Hip disability and Osteoarthritis Outcome Score; HRQL, health-related quality of life; HS, hamstring strength; I1, intervention group 1; I2, intervention group 2; IG, intervention group; KOOS, Knee injury and Osteoarthritis Outcome Score; KSS, Knee Society Clinical Rating score; LAPAQ, Longitudinal Ageing Study Amsterdam Physical Activity questionnaire; LEFS, Lower Limb Functional Scale; LOS, length of stay; MCS, mental component summary; Mini-OAKHQOL, Mini-Osteoarthritis of Knee and Hip Quality of Life; 6MWT, Six-Minute Walk Test; NEADL, Nottingham Extended Activities of Daily Living; NMES, neuromuscular electrical stimulation; N/R, not reported; NRS, Numeric Rating Scale for Pain; PCS, physical component summary; PCS, Physical composite score; PPT, pain pressure threshold; PRT, progressive resistance training; PSC, patient-specific complaints; PT, physiotherapist/physical therapist; PWC-170, Physical Work Capacity on an Aerobic Bicycle Ergometer; QS, quadriceps strength; RM, repetition maximum; ROM, range of motion; RT, resistance training; SCT, stair climb test; SD, standard deviation; SEEQ, Self-Efficacy Expectation questionnaire; SF-36, 36-iten Short Form Health Survey; SPW, self-paced walk; ST, strength training; STAI, State-Trait Anxiety Inventory; STS, sit-to-stand test; TUG, Timed-Up-and-Go test; VAS, visual analogue scale for pain; WOMAC, Western Ontario and Mcmaster Universities Osteoarthritis Index.

Patients with osteoarthritis often decrease their physical activity when faced with pain, leading to an overly sedentary lifestyle, excess weight gain, and increased muscle weakness, all of which contribute to a further increase in pain and disability.[13] Exercise as a means of managing pain, improving function and overall QoL in patients with osteoarthritis, is well established.[14] International guidelines recommend exercise for the management of pain and function in hip and knee osteoarthritis.[15] Emerging evidence suggests that preoperative optimization may improve patient disposition for surgery and reduce hospital length of stay (LOS).[16-18] Prehabilitation aims to enhance patients' functional capacity before surgery to reduce postoperative pain, prevent complications, and reduce hospital LOS.[19,20] Prehabilitation for those awaiting arthroplasty is increasingly recommended, and may have benefits before and after surgery.[21]

Table II. Methodological quality according to the PEDro criteria.

	PEDro criteria											
Study	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total (/10)**
An et al (2021)[66]	1	1	1	1	1	0	1	1	1	1	1	9
Aoki et al (2009)[49]	1	1	0	1	0	0	1	1	1	1	1	7
Borjesson et al (1996)[50]	1	1	0	1	0	0	1	1	1	1	1	7
Bruce-Brand et al (2012)[67]	1	1	1	1	0	0	1	0	0	1	1	6
Ho et al (2022)[48]	1	0	0	1	0	0	1	1	0	1	1	5
Crotty et al (2009)[47]	1	1	1	1	0	0	0	1	1	1	1	7
Doiron-Cadrin et al (2020)[68]	1	1	1	1	0	0	1	1	1	1	1	8
Gilbey et al (2003)[51]	1	1	0	1	0	0	0	0	0	1	1	4
Gocen et al (2004)[52]	1	1	0	0	0	0	1	1	1	1	1	6
Hoogeboom et al (2010)[53]	1	1	1	1	0	0	1	1	0	1	1	7
Huang et al (2012)[54]	1	0	0	1	0	0	0	1	0	1	1	4
Matassi et al (2012)[55]	1	1	0	1	0	0	1	1	0	1	1	6
Mikkelsen et al (2014)[56]	1	1	1	1	1	0	1	1	1	1	1	9
Nuñez et al (2006)[57]	1	1	0	1	0	0	1	0	0	1	1	5
Oosting et al (2012)[58]	1	1	1	1	0	0	1	1	1	1	1	8
Rittharomya et al (2020)[58]	1	1	0	1	0	0	1	1	1	1	1	7
Soeters et al (2018)[60]	1	1	0	1	0	0	0	1	1	1	1	6
Swank et al (2011)[61]	1	1	0	1	0	0	0	1	1	1	1	6
Topp et al (2009)[62]	1	1	0	1	0	0	0	1	0	0	1	4
Tungtrongjit et al (2012)[63]	1	1	1	1	0	0	1	0	0	1	1	6
Walls et al (2010)[64]	1	1	0	1	0	0	1	0	0	1	1	5
Weidenhielm et al (1993)[65]	1	1	0	1	0	0	0	1	0	1	1	5

PEDro criteria: 1. Eligibility criteria were specified. 2. Random allocation. 3. Concealed allocation. 4. Baseline similarity between groups. 5. Subject blinding. 6. Therapist blinding. 7. Assessor blinding. 8. Follow-up > 85%. 9. Intention-to-treat analysis. 10. Between-group statistical comparisons. 11. Point measures and measures of variability reported. Item scoring: 1 = present, 0 = absent. Criterion 1 is not included in the total score.

The effectiveness of prehabilitation to improve outcomes following THA and TKA has been examined by several systematic reviews with varying conclusions.[22-30] Most reviews assess only postoperative outcomes, which may be affected by surgery quality, postoperative complications, pain, mismatch of expectations, and motivation to return to rehabilitation.[31] Prehabilitation varies substantially in content and is currently predominantly home-based. No previous reviews have examined the effects of home-based exercise programmes but include studies with heterogeneous interventions. This study aims to systematically review and meta-analyze randomized controlled trials (RCTs) of home-based prehabilitation on pre- and postoperative outcomes in participants awaiting TKA and THA.

Methods

A systematic review of RCTs was undertaken and is reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA),[32,33] and in accordance with the preregistered protocol.[34]

Search strategy. MEDLINE, CINAHL, ProQuest, PubMed, Cochrane Library, and Google Scholar were searched from inception to October 2022. The key literature search terms were obtained from systematic reviews with meta-analysis,[23,26] and adapted with additional search words related to the study aims (Supplementary Material). Searches used the following combined and/or truncated key terms: rehabilitation OR prehabilitation OR preoperative OR presurgical care OR exercise OR training OR physical therapy OR physiotherapy, AND total knee arthroplasty OR total knee arthroplasty AND total hip arthroplasty OR total hip arthroplasty AND joint arthroplasty OR joint arthroplasty, AND home-based OR self-management OR tele-rehab OR tele-prehab OR online OR virtual OR community OR remote. Reference lists were manually searched for additional studies.

Eligibility and study selection. RCTs and pilot RCTs that examined the effect of prehabilitation interventions involving a partial or fully unsupervised home-based exercise programme on pre- and postoperative outcomes in participants awaiting TKA or THA were included. Full-text, English-language journal articles, with a patient population aged older than 18 years, were selected. We excluded articles that reported fully supervised programmes delivered in a hospital or clinical setting that required expert equipment or techniques such as proprioception training, acupuncture, neuromuscular electrical stimulation (without exercise), and education-only programmes. We classed prehabilitation interventions as any prescribed aerobic, strength, resistance, or flexibility exercises that required physical effort. Trials without a control group were excluded.

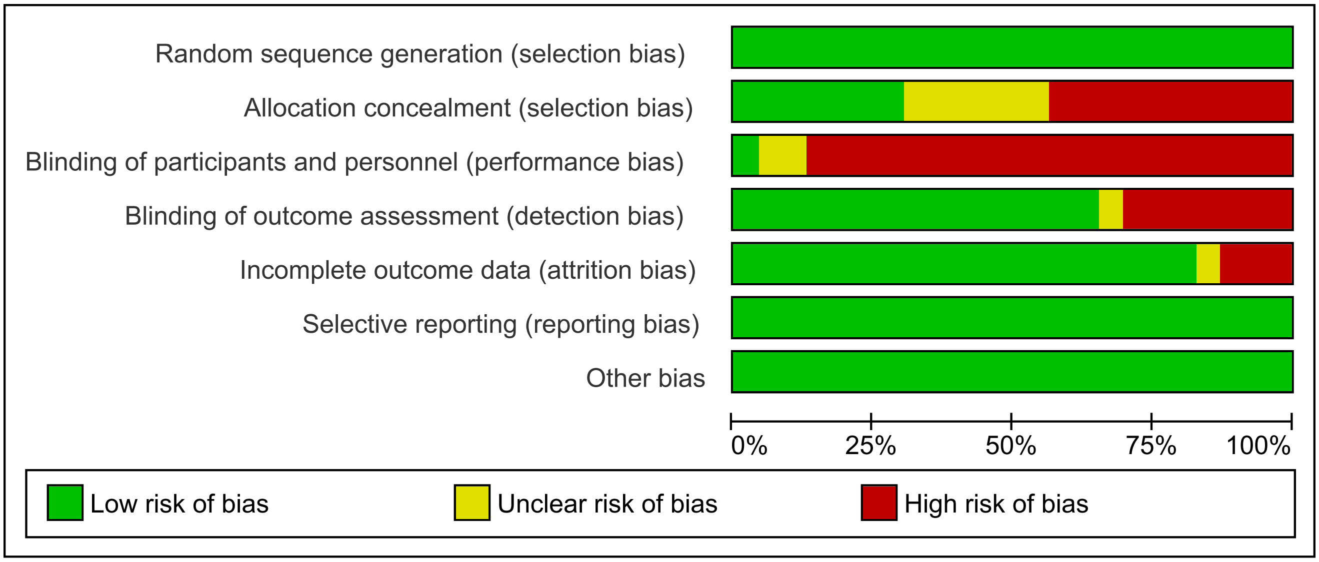

Fig. 2

Risk of bias graph.

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
3.1.1 Pain preoperative to TKA (WOMAC, VAS, Pain during walking, NPRS)								
An 2021	11	1.14	18	12.67	1.6	18	7.7%	-1.18 [-1.89, -0.46]
Aoki 2009	43.5	21.35	17	49.5	17.27	19	7.8%	-0.30 [-0.96, 0.35]
Börjesson 1996	3	1.5	34	3.3	1.5	34	8.2%	-0.20 [-0.67, 0.28]
Bruce-Brand 2012	10.78	4.31	10	8.33	4.36	6	6.9%	0.54 [-0.50, 1.57]
Doiron-Cadrin 2020	6.5	7.4	12	9.8	4.8	11	7.4%	-0.51 [-1.34, 0.33]
Huang 2012	6.4	1	126	6.5	1	117	8.5%	-0.10 [-0.35, 0.15]
Nuñez 2006	10.07	3.33	43	10.89	3.73	37	8.3%	-0.23 [-0.67, 0.21]
Rittharomya 2020	2.15	2.16	48	5.2	3.08	44	8.3%	-1.15 [-1.59, -0.70]
Swank 2011	4.3	0.38	36	5.1	0.42	35	8.0%	-1.98 [-2.55, -1.40]
Topp 2009	4.77	0.45	26	6.8	0.43	28	6.9%	-4.55 [-5.59, -3.51]
Tungtrongjit 2012	30.3	6.3	30	129	32.6	30	7.2%	-4.15 [-5.07, -3.23]
Walls 2010	11.4	3.3	9	11.8	4	5	6.8%	-0.11 [-1.20, 0.99]
Weidenhielm 1993	3.5	2.3	19	3.1	1.1	20	7.9%	0.22 [-0.41, 0.85]
Subtotal (95% CI)			**428**			**404**	**100.0%**	**-1.02 [-1.63, -0.40]**
Heterogeneity: Tau² = 1.13; Chi² = 176.58, df = 12 (P < 0.00001); I² = 93%								
Test for overall effect: Z = 3.25 (P = 0.001)								
3.1.2 Pain preoperative to THA (WOMAC, VAS, HOOS)								
Doiron-Cadrin 2020	9	3.1	12	9	2.9	11	12.0%	0.00 [-0.82, 0.82]
Gocen 2004	1.24	1.6	29	1.3	1.73	30	30.8%	-0.04 [-0.55, 0.47]
Hoogeboom 2010	37.7	18	10	49.3	24.7	11	10.5%	-0.51 [-1.38, 0.36]
Mikkelsen 2014	88.7	12	32	86.3	16	30	32.2%	0.17 [-0.33, 0.67]
Oosting 2012	66.8	9.2	15	67.8	12.2	13	14.5%	-0.09 [-0.83, 0.65]
Subtotal (95% CI)			**98**			**95**	**100.0%**	**-0.02 [-0.31, 0.26]**
Heterogeneity: Tau² = 0.00; Chi² = 1.80, df = 4 (P = 0.77); I² = 0%								
Test for overall effect: Z = 0.16 (P = 0.87)								

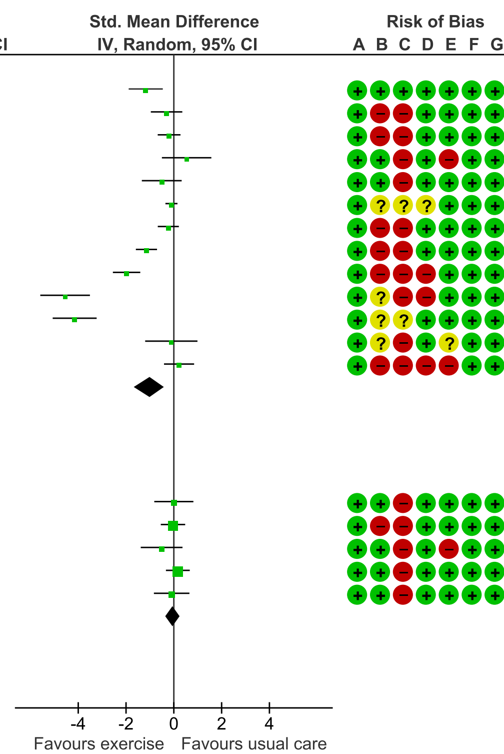

Fig. 3

Effect of prehabilitation vs standard care on pain prior to total knee arthroplasty (TKA) and total hip arthroplasty (THA). CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; IV, inverse variance; NPRS, Numeric Pain Rating Scale; SD, standard deviation; VAS, visual analogue scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Outcomes of interest included pain, function, QoL, hospital LOS, and programme compliance. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[35] subdomains for pain and function and 36-Item Short Form survey (SF-36)[36] for QoL were extracted from each study where applicable. Otherwise, alternate measures such as visual analogue scale (VAS),[37] numeric pain rating scale (NPRS),[37] Harris Hip Score (HHS),[38] and Hip Disability and Osteoarthritis Outcome Score (HOOS)[39] were converted to WOMAC pain,

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
4.1.1 Pain post operative to TKA (WOMAC,VAS, pain during walking, NPRS)								
An 2021	3.5	1.33	18	7.05	2.55	18	14.7%	-1.71 [-2.48, -0.93]
Huang 2012	2.4	0.7	126	2.5	0.6	117	21.6%	-0.15 [-0.40, 0.10]
Topp 2009	1.53	0.34	26	1.38	0.33	28	18.0%	0.44 [-0.10, 0.98]
Tungtrongjit 2012	2.5	3.1	30	4.8	4.2	30	18.3%	-0.62 [-1.13, -0.10]
Walls 2010	5.4	4	9	5.2	4.3	5	10.8%	0.05 [-1.05, 1.14]
Weidenhielm 1993	1.4	2	19	1.1	1.3	20	16.7%	0.18 [-0.45, 0.80]
Subtotal (95% CI)			**228**			**218**	**100.0%**	**-0.28 [-0.78, 0.21]**
Heterogeneity: Tau² = 0.28; Chi² = 24.06, df = 5 (P = 0.0002); I² = 79%								
Test for overall effect: Z = 1.12 (P = 0.26)								
4.1.2 Pain post operative to THA (VAS, HOOS)								
Gocen 2004	85.3	11.78	29	78.7	9.41	30	37.1%	0.61 [0.09, 1.14]
Mikkelsen 2014	91.7	10	32	91.4	13	30	38.8%	0.03 [-0.47, 0.52]
Oosting 2012	34.5	8.6	14	37.3	16.8	12	24.1%	-0.21 [-0.98, 0.57]
Subtotal (95% CI)			**75**			**72**	**100.0%**	**0.19 [-0.28, 0.66]**
Heterogeneity: Tau² = 0.08; Chi² = 3.92, df = 2 (P = 0.14); I² = 49%								
Test for overall effect: Z = 0.78 (P = 0.44)								

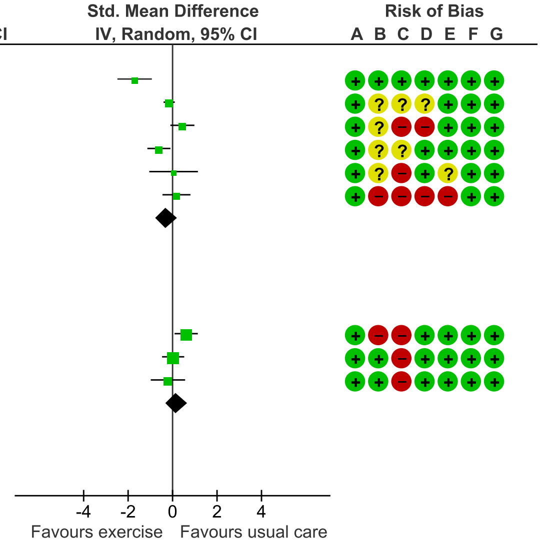

Fig. 4

Effect of prehabilitation versus standard care on pain post total knee arthroplasty (TKA) and total hip arthroplasty (THA). CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; IV, inverse variance; NPRS, Numerical Pain Rating Scale; SD, standard deviation; VAS, visual analogue scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

WOMAC function, and SF-36 for estimation of the overall effect and to allow for comparison across studies.[40] To convert effect estimates back to WOMAC pain and function scale (0 to 100) or SF-36 (0 to 100), the standardized mean differences (SMDs) were multiplied by the median standard deviation (SD).[41] Where pain was reported during specific activities such as walking, sit-to-stand, stair ascent, and stair descent, pain during walking was used.

One investigator (TCDK) performed the searches. Two reviewers (TCDK and KTK) independently assessed eligibility in two phases: screening of titles and abstracts, and then full-text review. Disagreements were discussed between the reviewers, and in the event of disagreement consensus was achieved by consulting a third independent reviewer (DMD).

Data extraction. Means and SDs, mean differences, or effect sizes for the outcomes of interest were independently extracted by two reviewers (TCDK and KTK). We extracted the following from each article: sample size; participant demographics; intervention details; follow-up period; time to surgery; intervention compliance; and adverse events. Preoperative outcomes were extracted following prehabilitation intervention and prior to surgery. Postoperative outcomes were extracted at the longest follow-up timepoint for each study up to six months postoperatively. Where information was insufficient, authors were contacted. If authors could not be reached, information was imputed from original figures or obtained from previous review articles where possible.

Statistical analysis. SMDs (effect sizes) and 95% confidence intervals (CIs) were calculated from pre-and postintervention means and SDs using the RevMan 5 software (Nordic Cochrane centre, Denmark).[42] Authors were contacted for full data sets where applicable. Negative SMD values indicated outcomes that favoured the prehabilitation intervention group. We considered values of < 0.2 a small effect size, 0.2 to 0.5 a moderate effect size, and > 0.8 a large effect size.[43]

Meta-analysis was performed using a random effects model. Data were combined in a meta-analysis when at least two trials were clinically homogeneous. If clinical heterogeneity prevented reasonable combining of data, the results were reported in descriptive format. Heterogeneity is reported using the chi-squared test and I^2 statistic. An I^2 statistic of 50% to 74% indicates substantial heterogeneity and > 75% considerable heterogeneity. Statistical significance was accepted at $p < 0.05$.

Two reviewers (TCDK, KK) independently evaluated the methodological quality of included studies using the PEDro scale,[44,45] and risk of bias using the Cochrane Risk of Bias tool (ROB2).[46] PEDro scores are reported on a 0 to 10 scale (criterion one is not scored), with > 9 indicating excellent methodological quality, 6 to 8 good quality, 4 to 5 fair, and < 4 poor. The ROB2 tool reports a low, unclear, or high risk of bias.

Results

Study selection. The search yielded a total of 889 results. Of these, 127 trials were retrieved for full-text review and 22 trials fulfilled the inclusion criteria for the systematic review. One trial did not report separate outcomes for hip and knee arthroplasty,[47] and in another study

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
5.1.1 Function preoperative to TKA (WOMAC)								
An 2021	40.67	4.81	18	48.16	6.34	18	17.3%	-1.30 [-2.03, -0.57]
Bruce-Brand 2012	33.91	12.91	10	26.11	15.33	6	12.5%	0.53 [-0.50, 1.57]
Doiron-Cadrin 2020	23.5	7.9	12	37.2	13.6	11	14.4%	-1.20 [-2.10, -0.30]
Nuñez 2006	35.26	10.46	43	40.89	12.64	37	22.6%	-0.48 [-0.93, -0.04]
Tungtrongjit 2012	93.3	22.7	30	93.8	24.9	30	21.4%	-0.02 [-0.53, 0.49]
Walls 2010	34.7	11	9	38.4	14.4	5	11.7%	-0.28 [-1.38, 0.82]
Subtotal (95% CI)			**122**			**107**	**100.0%**	**-0.48 [-0.97, 0.02]**
Heterogeneity: Tau² = 0.23; Chi² = 14.28, df = 5 (P = 0.01); I² = 65%								
Test for overall effect: Z = 1.89 (P = 0.06)								
5.1.2 Function preoperative to THA (WOMAC, HOOS, Harris Hip Score)								
Doiron-Cadrin 2020	29	7.3	12	31.8	7.9	11	9.2%	-0.36 [-1.18, 0.47]
Gilbey 2003	29	12.14	32	36	12.14	25	22.0%	-0.57 [-1.10, -0.03]
Gocen 2004	13	14.4	29	15.4	12.2	30	24.0%	-0.18 [-0.69, 0.33]
Hoogeboom 2010	51.1	10.5	10	52.3	21.2	11	8.5%	-0.07 [-0.92, 0.79]
Mikkelsen 2014	89.1	10	32	86.5	13	30	25.1%	0.22 [-0.28, 0.72]
Oosting 2012	65.2	10.6	15	68.7	14.9	13	11.2%	-0.27 [-1.01, 0.48]
Subtotal (95% CI)			**130**			**120**	**100.0%**	**-0.18 [-0.43, 0.07]**
Heterogeneity: Tau² = 0.00; Chi² = 4.81, df = 5 (P = 0.44); I² = 0%								
Test for overall effect: Z = 1.41 (P = 0.16)								

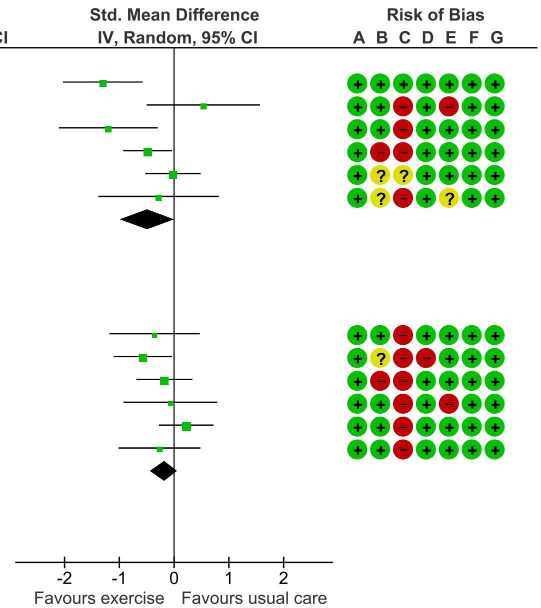

Fig. 5

Effect of prehabilitation vs standard care on function prior to total knee arthroplasty (TKA) and total hip arthroplasty (THA). CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; IV, inverse variance; SD, standard deviation; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

the reviewers were unable to obtain the raw data sets.[48] Therefore, 20 trials were included in the meta-analysis (Figure 1).

Study characteristics. From 22 RCTs involving 1,601 participants, 1,049 were awaiting TKA, 240 awaiting THA, and 312 awaiting either hip or knee arthroplasty which was not differentiated within the studies. The mean age of participants was 66.8 years (SD 5.67) and 68.5% (1,097) were female.

Intervention designs are described in Table I. A total of 19 trials compared prehabilitation interventions with usual care,[47–65] while three trials compared two intervention methods to usual care.[66–68]

For participants awaiting TKA, 14 trials studied prehabilitation interventions compared to usual care.[48–50,54,55,57,59,61–67] The exercise interventions included a combination of physiotherapy-led supervised sessions followed by remote unsupervised home-based exercises,[49,50,55,57,59,61,62,65] as well as fully home-based programmes.[63,66] Other interventions in addition to home-based exercise included telerehabilitation,[66] home-based resistance training and neuromuscular electrical stimulation,[64,67] an integrated education programme,[48,54,59] self-management plans,[47] and telephone monitoring.[47,59]

For participants awaiting THA, five trials studied prehabilitation interventions compared to usual care.[51–53,56,58] The exercise interventions included a combination of physiotherapy led supervised sessions followed by remote unsupervised home-based exercises[51,53,58,69] and home-based exercise and education.[52]

Three trials evaluated prehabilitation interventions versus usual care in both hip and knee arthroplasties.[47,60,68] The exercise interventions included preoperative online exercises using a microsite,[60] home-based exercises directed by a self-management plan and monthly telephone monitoring[47] and supervised telecommunication (online) exercises followed by unsupervised home-based exercises.[68]

Intervention compliance and adverse events. Compliance was reported in only 11 studies, but a mean value of 90.5% was highlighted in those that recorded this data.[49,51,53,56,58,60,61,64,66–68] During the preoperative period, reasons for not continuing with the intervention were surgery cancellation or postponement, having surgery brought forward, time commitments, and other medical reasons. In the postoperative period, complications following surgery resulted in participants being lost to follow-up.

No serious adverse events occurred as a result of the exercise intervention in the five studies that reported these data.[51,53,57,58,68] Post-exercise soreness was treated with massage, relaxation techniques, stretching exercises, medication, or a combination of these interventions.

Methodological quality and risk of bias. There were two excellent-quality trials (> 9/10) and 14 good-quality trials (> 6/10) with a mean score of 6/10 (SD 1.48) for all trials on the PEDro scale. Almost all trials adhered to random allocation, between-group comparisons, and measures of variability for at least one key outcome. Most trials did not blind participants or therapists which was expected,

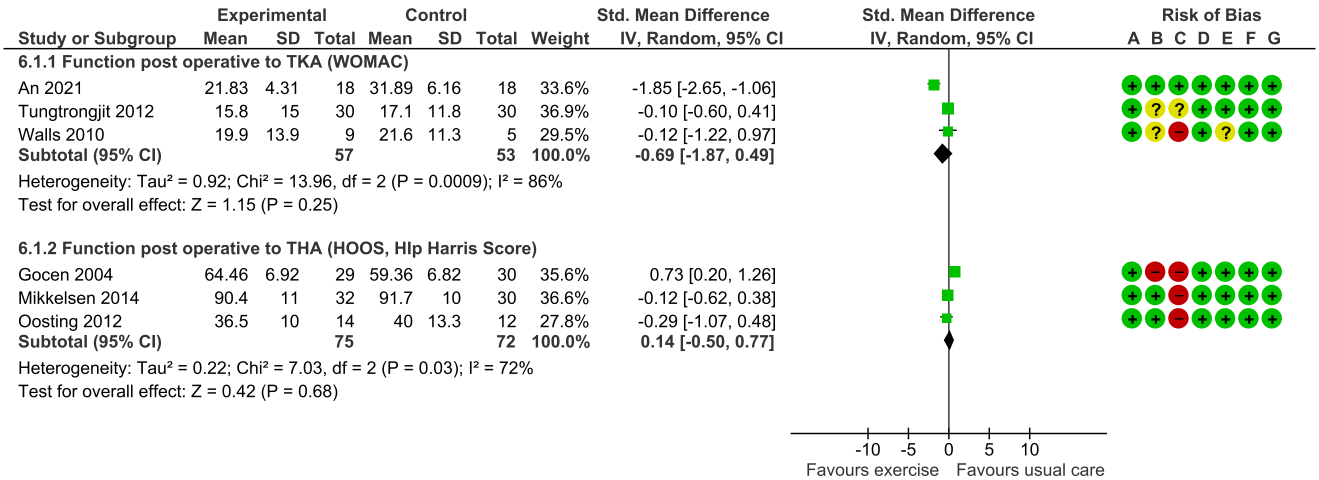

Fig. 6

Effect of prehabilitation vs standard care on function post total knee arthroplasty (TKA) and total hip arthroplasty (THA). CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome score; IV, inverse variance; SD, standard deviation; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

given the nature of rehabilitation interventions in clinical populations. Allocation concealment was used by eight trials and outcome assessors were blinded in 15 of the trials. Intention-to-treat analysis was performed by 11 trials and measures of at least one key outcome from > 85% of participants were obtained in 17 trials (Table II). The risk of bias graph is shown in Figure 2 and the risk of bias for each study is shown next to the forest plots (Figures 3 to 9). All trials were judged as low risk for sequence generation, selective reporting, and other biases, while 18 of the trials were judged as low risk for incomplete data. Low risk was judged for blinding of outcome assessors in 15 trials. The combined risk of bias summary table is available in the supplementary material (Supplementaty Figure a).

Effect of prehabilitation on pain. A total of 13 trials with 832 participants showed that prehabilitation compared with usual care improved pain prior to TKA (SMD -1.02 (95% CI -1.63 to -0.40); p = 0.001), however no difference was observed in those awaiting THA, based on five trials with 193 participants (SMD -0.02 (95% CI -0.31 to 0.26); p = 0.87) (Figure 3). Effect sizes were larger for the TKA than THA, however considerable levels of heterogeneity (I^2 = 93%) were reported between the TKA trials compared to low heterogeneity (I^2 = 0%) between the THA trials.

There was no effect of prehabilitation on postoperative pain following either TKA or THA. Six trials with 446 participants showed a small improvement in pain after TKA that was not statistically significant, but was in favour of prehabilitation (SMD -0.28 (95% CI -0.78 to 0.21); p = 0.26). Three trials with 145 participants showed a small improvement in pain after THA, although again not statistically significant after THA (SMD 0.19 (95% CI -0.28 to 0.66); p = 0.44) (Figure 4). Considerable heterogeneity (I^2 = 79%) was observed between the TKA trials and moderate heterogeneity (I^2 = 49%) between the THA trials.

Effect of prehabilitation on function. Six trials with 229 participants awaiting TKA suggested an effect of prehabilitation compared to usual care on preoperative function (SMD -0.48 (95% CI -0.97 to 0.02); p = 0.06). In THA, six trials with 250 participants suggested a non-significant effect of prehabilitation (SMD -0.18 (95% CI -0.43 to 0.07); p = 0.16) (Figure 5). Effect sizes were larger for the TKA than THA, and substantial levels of heterogeneity were reported for the TKA trials (I^2 = 65%) while low heterogeneity was overserved between the THA trials (I^2 = 0%).

No significant effect was observed in improving function postoperatively. Three trials with 110 participants suggested that prehabilitation may improve function after TKA but the effect was not significant (SMD -0.69 (95% CI -01.89 to 0.49); p = 0.25). Three trials with 147 participants showed that prehabilitation had no effect on improving function after THA (SMD 0.14 (95% CI -0.50 to 0.77); p = 0.68) (Figure 6). Larger effect sizes were found in TKA trials and considerable heterogeneity existed in both TKA and (I^2 = 86%) and THA (I^2 = 74%).

Effect of prehabilitation on quality of life. No effect was seen on measures of QoL preoperatively. Two trials with 120 participants showed that prehabilitation compared to usual care had no effect on improving QoL prior to TKA (SMD 0.61 (95% CI -0.64 to 1.87); p = 0.34) (Figure 7). Considerable heterogeneity was observed (I^2 = 88%). Four trials with 134 participants showed that prehabilitation had no effect on improving QoL prior to THA (SMD 0.03 (95% CI -0.36 to 0.42); p = 0.87) and heterogeneity was low (I^2 = 19%) (Figure 8).

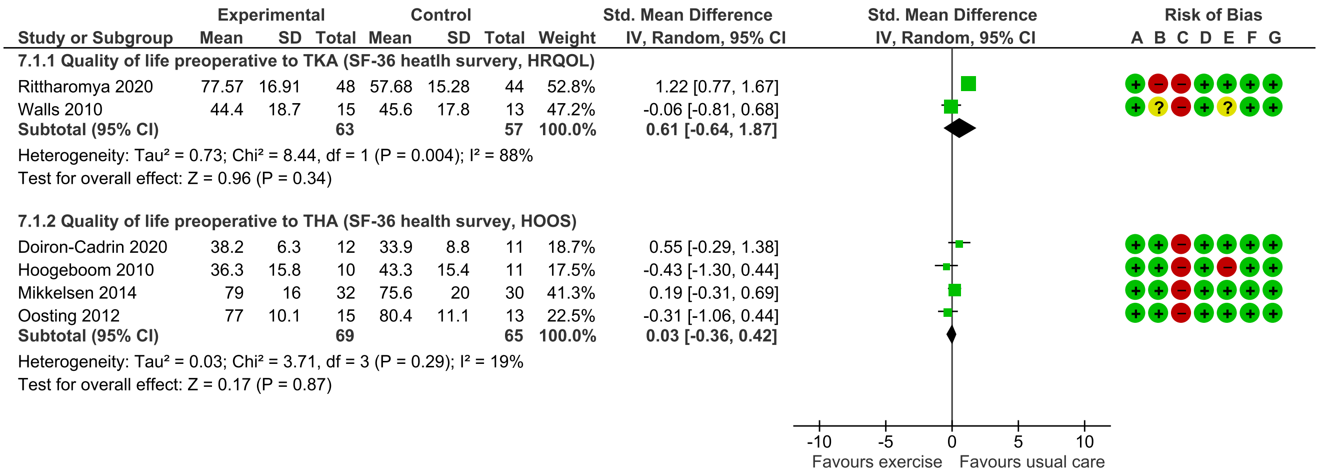

Fig. 7

Effect of prehabilitation vs standard care on quality of life prior to total knee arthroplasty (TKA) and total hip arthroplasty (THA). CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; HRQOL, health-related quality of life; IV, inverse variance; SD, standard deviation; SF-36, 36-Item Short-Form survey.

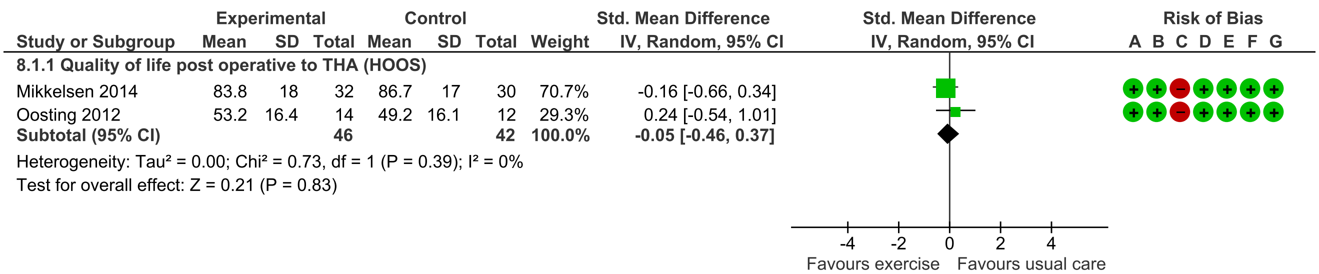

Fig. 8

Effect of prehabilitation vs standard care on quality of life post total hip arthroplasty (THA). CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; IV, inverse variance; SD, standard deviation.

Quality of life post TKA was reported by one study,[64] and was thus not included in the meta-analysis. Significant improvement in QoL at 12 weeks after surgery was reported, however the study had a very small sample size (n = 28) that may have inflated effect sizes. Two trials with 88 participants showed no difference in QoL after THA (SMD -0.05 (95% CI -0.46 to 0.37); p = 0.83) (Figure 8) and with low heterogeneity (I^2 = 0%).

Effect of prehabilitation on length of hospital stay. Four trials with 505 participants showed significant improvement (p < 0.0001) for hospital LOS (days) in favour of prehabilitation following TKA (SMD -0.43 (95% CI -0.64 to -0.23); Figure 9). Low heterogeneity (I^2 = 19%) was observed. Three trials with 176 participants showed improvement, although not significant, (p = 0.12) for hospital LOS (days) in favour of prehabilitation following THA (SMD -0.24 (95% CI -0.53 to 0.06); Figure 9). Low heterogeneity was observed (I^2 = 0%).

Discussion

This is the first comprehensive systematic review and meta-analysis focused on prehabilitation interventions with a home-based exercise component, one of the predominant methods of delivering exercise prehabilitation in the UK. Prehabilitation improves pain and possibly function in patients prior to TKA, although the evidence is less clear regarding any benefits in THA. Hospital LOS was reduced with prehabilitation, but postoperative patient-reported pain and function appear to be largely unaffected. No effect was found on measures of patient QoL prior to or post TKA and THA.

It is important to consider that the studies included in this review were conducted before the COVID-19 pandemic with the longest waiting times recorded at up to six months from diagnosis to surgery. Wait times longer than 180 days have been linked to significantly increased hospital LOS following TKA,[70] and possibly contribute to the further clinical deterioration of arthritis and associated musculoskeletal deconditioning.[66,67] Currently, healthcare systems globally face significantly longer waiting times for surgery and hospital LOS compared to before the pandemic.[71] Increased waiting times have enhanced the interest in prehabilitation to maintain and improve patients' functional status prior to

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
9.1.1 Hospital lenght of stay after TKA (days)								
Huang 2012	7	2	126	8	1	117	42.7%	-0.62 [-0.88, -0.37]
Matassi 2014	9.1	2.1	61	9.9	2.3	61	26.5%	-0.36 [-0.72, -0.00]
Soeters 2018	2.7	1.2	63	3	1.2	63	27.3%	-0.25 [-0.60, 0.10]
Walls 2010	8.1	9.6	9	8.8	5.9	5	3.5%	-0.08 [-1.17, 1.02]
Subtotal (95% CI)			**259**			**246**	**100.0%**	**-0.43 [-0.64, -0.23]**
Heterogeneity: Tau² = 0.01; Chi² = 3.70, df = 3 (P = 0.30); I² = 19%								
Test for overall effect: Z = 4.10 (P < 0.0001)								
9.1.2 Hospital lenght of stay after THA (days)								
Hoogeboom 2010	6	5.6	10	6	8.8	11	12.0%	0.00 [-0.86, 0.86]
Oosting 2012	5.1	1	14	5.4	2.1	15	16.5%	-0.18 [-0.91, 0.55]
Soeters 2018	2	1.2	63	2.3	0.8	63	71.5%	-0.29 [-0.64, 0.06]
Subtotal (95% CI)			**87**			**89**	**100.0%**	**-0.24 [-0.53, 0.06]**
Heterogeneity: Tau² = 0.00; Chi² = 0.42, df = 2 (P = 0.81); I² = 0%								
Test for overall effect: Z = 1.57 (P = 0.12)								

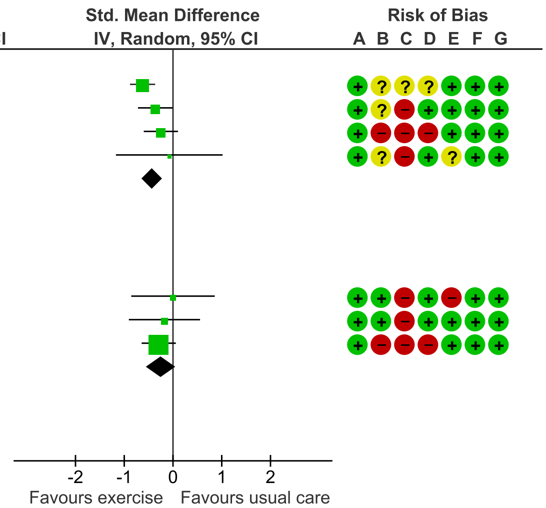

Fig. 9

Effect of prehabilitation vs standard care on hospital length of stay (days) post total knee arthroplasty (TKA) and total hip arthroplasty (THA). CI, confidence interval; IV, inverse variance; SD, standard deviation.

arthroplasty.[72,73] To promote presurgical optimization the concept of "waiting well" has been encouraged in the UK. Some basic online support services are available in certain areas, such as My Planned Care app in England, however there are no comprehensive home-based prehabilitation services, to the authors' knowledge, that are available to support patients currently while they wait for their arthroplasty.

Knee strength and functional performance is anticipated to decline in the preoperative period due to disuse atrophy.[62,74] The surgical insult and subsequent recovery will affect physical performance in the early postoperative phase and the extent of this will vary across the population. Prehabilitation may have a prophylactic role in expediting subsequent postoperative recovery of function in certain groups, such as the elderly, however this level of data was not captured in the wider meta-analysis. Regaining muscular strength after disuse is lower in elderly patients compared to younger counterparts.[75] Therefore, older patients may benefit more from the effects of prehabilitation on improved pain, function and presurgical presentation, which may also translate into better postoperative outcomes.[12] The effect of the prehabilition on pain and function is likely to be greater in the preoperative period as there is room for improvement, whereas postoperatively the effect of the arhroplasty on these outcomes may be difficult to measure using current patient-reported outcome measures (PROMs). This may be in part related to the ceiling effect of commonly used PROMs.[76,77] Furthermore, QoL of patients with osteoarthritis has been shown to reduce with every additional month spent on the waiting list.[3] Poorer QoL is expected for frail patients who have severe symptoms such as joint pain, stiffness, and limited functional and self-care ability.[78] Consequently, longer wait times put patients at risk of further symptom deterioration and and therefore it is plausible that the protective effect of prehabilitation is more pronounced in frail patients.

Compliance with prehabilitation interventions was reported by only 11 of the 22 included trials, however, in those that did report these data, high levels of compliance were seen (90.5%). To obtain the optimal benefits of exercise, an appropriate exercise prescription according to the latest clinical guidelines is recommended.[15] Hurley et al[79] showed that combining exercise and self-management programmes in a home-based environment might enhance the benefits of prehabilitation given that exercise instructions are easy to follow.[79] Therefore, increased surgical waiting times can potentially be used for more comprehensive physical optimization before surgery comprising patient-specific exercise prescriptions, goal setting, and behaviour change approaches.

Previous reviews have studied the effect of prehabilitation on postoperative pain, function, and hospital LOS.[22,24,25,28-30] However, we evaluated the effectiveness of prehabilitation prior to TKA and THA in addition to outcomes following surgery to account for factors associated with surgical success, complications, and recovery. The included studies in this review had reasonably good methodological quality (6/10 PEDro scores). Most concerns arose from the lack of patient and therapist blinding, which is usually not possible in exercise interventions. Programme design based on access to equipment, facilities, and level of supervision varied greatly in previous reviews and this may affect the ability to combine research evidence effectively in a meta-analysis.[22-26,29,30] A better understanding of programme design provides important insights into programme effectiveness to elicit long-term exercise-related improvements.[80] The specific effect of home-based prehabilitation interventions in patients with osteoarthritis have not been reported previously in meta-analyses. In addition, follow-up periods were not defined and compliance with exercise interventions were under-reported in previous reviews.[22-24,26,27,29,30] Finally, the sample sizes of the included studies were generally small, which may inflate effect sizes, and the methodological quality of previous reviews varied considerably.[22–26,29]

There were specific limitations in the trials included in this study that contributed to heterogeneity. Due to the lack of large RCTs, most studies were inadequately powered to detect small-to-medium effect sizes and increased the chance that baseline differences between groups affected pre- and post intervention results. Age groups varied considerably across studies. This is important to note since elderly patients with more pronounced disuse atrophy may gain more from prehabilitation.[74] Most studies provided insufficient information on exercise interventions, such as whether exercises were individual or group-based, who supervised the sessions, and the durations of supervised sessions. A diverse range of exercise interventions was carried out with no uniformity in intervention time, frequency, or type of exercise. It is assumed that most studies followed best practice guidelines at the time, however outcomes were based on addressing patient dysfunction and improving symptoms. Compliance was not reported by 11 of the 22 studies. The direct comparison of the effect of prehabilitation on TKA versus THA was not examined by any of the studies. It is recommended that future trials should use the guidelines (TIDieR Checklist) for describing interventions,[81] and newer evidence-based approaches are needed to demonstrate the benefits of prehabilitation.

Prehabilitation in a home-based environment seems to be feasible and safe, improves pain and function before TKA and THA, reduces LOS, and compliance with such programmes is excellent. The evidence is less clear about the effects of prehabilitation on QoL and outcomes after arthroplasty. However, high evidence heterogeneity, limited power, as well as lack of adequate intervention description in studies does not allow firm conclusions about the optimal delivery of prehabilitation programmes. Further research on multimodal prehabilitation exercise programmes is warranted.

Take home message

- Home-based prehabilitation prior to arthroplasty may improve pain and function before surgery, which can lead to reduced hospital length of stay.
- These conclusions are based on short hospital waiting times and it may be, in the current climate of prolonged waiting times before surgery, that prehabilitation has an important role in maintaining patient function.

Supplementary material

Search strategies and risk of bias summary table.

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