Supplementary Material

**MEDLINE (Via Ovid) search strategy**

Population:

1. Chronic pain/

2. Persistent pain/

3. 1 or 2

4. exp Arthralgia/

5. Joint pain

6. Musculoskeletal pain/

7. Arthralgia

8. Musculoskeletal pain

9. Joint diseases

10. exp osteoarthritis

11. osteoarthritis

12. exp back pain

13. back pain

14. low back pain

15. lumbago

16. lumbar pain

17. ((neck or cervical or thoracic or spin\* or lumbar or low\* back or shoulder or elbow or hand or hip or knee or foot or musculoskeletal or joint) adj3 pain)

18. non-specific low\* back pain

19. neck pain

20. 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19

Intervention

21. (Physical\* adj2 activit\*)

22. (Leisure adj1 activit\*)

23. (physical adj1 (fitness or training))

24. exp Exercise

25. exercise\*

26. (strength\* adj1 (exercis\* or training))

27. (aerobic adj1 (exercis\* or training or fitness))

28. exp exercise therapy

29. Stretching

30. exp Walking

31. walking

32. “Activities of daily living”

33. Activit\* of daily living

34. Self-management

35. (Sedentary or inactive\* (behavio?r or lifestyle))

36. (physical\* inactivit\*)

37. (sitting adj1 time)

38. 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 1 or 32 or 33 or 34 or 35 or 36 or 37

Study type: RCTs filter

1. clinical trial, phase iiii.sh
2. (phase 3 or phase3 or phase iii or p3 or piii).ti,ab,kw.
3. randomized controlled trial.pt
4. controlled clinical trial.pt
5. randomized.ab
6. placebo.ab
7. clinical trials as topic.sh
8. randomly.ab
9. trial.ti
10. 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47

49. 3 or 20

50. 38 and 49

51. 48 and 50

**Tables:**

Behaviour change techniques in each study

|  |  |  |
| --- | --- | --- |
| **Study** | **BCTs in intervention** | **BCTs in control**  |
| Baker 2020 | 1.1, 1.2, 2.1, 2.3, 2.5, 3.1, 4.1, 9.1 | 7.1, 9.1 |
| Barone Gibbs 2018 | 1.1, 1.8, 3.1, 5.1, 7.1, 9.1, 12.5 | No BCT |
| Basler 2007 | 3.1, 4.1, 5.1, 8.1, 9.1 | 4.1, 8.1, 9.1 |
| Bennell 2014 | 1.1, 1.2, 2.1, 2.2, 4.1, 9.1 | 1.1, 2.1, 4.1, 9.1 |
| Bennell 2017 | 1.1, 1.2, 1.5, 2.3, 2.5, 4.1, 6.1, 8.1, 9.1 | 1.2, 2.3, 2.5, 4.1, 6.1, 8.1, 9.1 |
| Bieler 2017 | ST: 1.4, 2.4, 4.1, 9.1NW: 1.4, 2.4, 4.1, 8.1, 9.1 | 4.1, 9.1 |
| Bossen 2013 | 7.1, 8.7, 10.3 | No BCT |
| Cederbom 2019 | 1.1, 1.2, 1.4, 4.1, 5.1, 8.7, 9.1 | 5.1, 7.1, 9.1 |
| Chen 2020 | 1.4, 2.2, 4.1, 5.1, 6.1, 8.1, 9.1 | 1.4, 2.2, 4.1, 8.1 |
| Farr 2010 | 1.2, 2.3, 2.4, 2.5, 3.1, 4.1, 5.1, 6.1, 8.1, 9.1, 11.2, 12.5 | 1.2, 3.1, 4.1, 5.1, 9.1, 11.2 |
| Hinman 2007 | 2.3, 2.4, 3.1, 4.1, 9.1, 12.6 | No BCT |
| Hinman 2020 | 1.3, 1.4, 2.3, 2.5, 4.1, 5.2, 6.1, 9.1, 12.5 | 5.1 |
| Hughes 2006 | 1.2, 1.3, 1.4, 1.8, 2.2, 2.3, 2.4, 2.7, 4.1, 6.1, 8.1, 8.7, 9.1, 12.5 | 4.1 |
| Kloek 2018 | 1.3, 2.2, 2.3, 3.1, 4.1, 5.1, 6.1, 8.1, 8.7  | No BCT |
| Krein 2013 | 1.1, 2.2, 2.3, 3.1, 3.3, 4.1, 5.1, 6.1, 8.7, 13.2 | No BCT |
| Lang 2021 | 1.1, 1.5, 2.3, 4.1, 5.1, 9.1, 11.1, 13.2 | 5.1, 9.1, 11.1, 13.2 |
| Meng 2011 | 4.1, 6.1, 8.1, 9.1 | 4.1, 9.1 |
| Nelligan 2021 | 2.3, 3.1, 4.1, 6.1, 7.1, 9.1 | 5.1, 9.1 |
| Pisters 2010 | 1.1, 1.2, 2.3, 4.1, 8.7, 9.1, 10.4 | 4.1 |
| Schaller 2017 | 1.2, 3.1, 5.1, 9.1 | 5.1, 9.1 |
| Semrau 2021 | 1.2, 1.3, 1.4, 1.7, 2.2, 2.3, 2.4, 2.7, 5.1, 5.4, 6.1, 8.1, 9.2 | 4.1, 5.1, 6.1 |
| Wallis 2017 | 1.1, 1.4, 2.3, 3.1, 7.1, 9.1 | No BCT |
| Zacharia 2018 | 1.1, 2.3, 3.1, 4.1, 5.1, 6.1, 8.1, 9.1 | 2.3, 4.1, 5.1, 6.1, 8.1, 9.1  |
| Taxonomy numbers: 1.1: Goal setting (behaviour); 1.2: problem solving; 1.3: goal setting (outcome); 1.4: action planning; 1.5: review behaviour goal(s); 1.7: review outcome goal(s); 1.8: behavioural contract; 2.1: monitoring of behaviour by others without feedback; 2.2: feedback on behaviour; 2.3: self-monitoring of behaviour; 2.4: self-monitoring of outcome(s) of behaviour; 2.5: monitoring outcome(s) of behaviour by others without feedback; 2.7: feedback on outcome(s) of behaviour; 3.1: social support (unspecified); 3.3: social support (emotional); 4.1: instruction on how to perform a behaviour; 5.1: information about health consequences; 5.2: salience of consequences; 5.4: monitoring of emotional consequences; 6.1: demonstration of behaviour; 7.1: prompts/cues; 8.1: behavioural practice/rehearsal; 8.7: graded tasks; 9.1: credible source; 9.2: pros and cons; 10.3: non-specific reward; 10.4: social reward; 11.1: pharmacological support; 11.2: reduce negative emotions; 12.5: adding objects to the environment; 12.6: body changes; 13.2: framing/reframingKey: BCT = behaviour change technique |

Health-related (secondary) outcomes in each study

|  |  |  |
| --- | --- | --- |
| **Study** | **Significant outcomes (Time point)** | **Non-significant outcomes** |
| Baker 2020 | No significant outcomes | WOMACTimed Up and Go test Repeated chair standStair climbStrength - Quadriceps Strength – hamstrings  |
| **Barone Gibbs 2018** | ODI (post-intervention) | Pain VAS50-foot walk testRepeated sit-to-stand test Timed Up and Go test Unloaded/loaded reach test |
| Basler 2007 | HFAQ (Longest follow-up)  | Spine range of movement – ultrasound topometry |
| Bennell 2014 | No significant outcomes | Pain VASWOMAC function |
| **Bennell 2017** | GROC function (Immediate Post-intervention and longest follow-up) | WOMACPain NRS – overallPain NRS – walking AQoL llGROC pain  |
| Bieler 2017 | Timed stair climbing test (post-intervention) NW-control8-foot Up and Go test (post-intervention) NW-controlMOS (post-intervention) NW-control6-minute walk test (post-intervention) NW-controlTask-specific self-efficacy (post-intervention) NW-control SF-36 role-physical (post-intervention) NW-control and ST-controlSF-36 vitality (post-intervention) NW-controlSF-36 mental health (post-intervention) NW-control | WOMACTask specific self-efficacy (ST-control)ASES SF-36 other scales and other interventions Chair stand performanceTimed stair climbing test (ST-control)8-foot Up and Go test (ST-control)MOS (ST-control)6-minute walk test (ST-control)SF-36 (other subscales and groups) |
| Bossen 2013 | ASES other symptoms (longest follow-up)HADS anxiety (Longest follow-up) | HOOS/KOOSPain NRSTiredness NRSMulti-dimensional Health Locus of Control ScaleHADS depression |
| Cederbom 2019 | BPI pain (post-intervention and longest follow-up)BPI disability (post-intervention)SF-12 physical (post-intervention)SF-12 mental (post-intervention) | BPI disability (longest follow-up)SPPBCatastrophizing thoughts 2 itemFalls Efficacy Scale - InternationalSF-12 physical (longest follow-up)SF-12 mental (longest follow-up) |
| **Chen 2020** | Exercise self-efficacy scale (post-intervention)Decisional Balance Scale for Exercise (post-intervention)WOMAC pain (post-intervention)WOMAC stiffness (post-intervention)Five Time Sit to Stand Test (post-intervention)Timed Up and Go test (post-intervention) | None not significant  |
| Farr 2010 | Muscle strength upper and lower body (post-intervention) – RT groups only – no between group difference measured | WOMAC pain |
| Hinman 2007 | Pain VAS – movement (post-intervention)WOMAC (post-intervention)AQoL (post-intervention)Strength – hip abductors (post-intervention)6-minute walk test (post-intervention) | Strength – quadriceps Timed Up and Go test Step test  |
| **Hinman 2020** | WOMAC function (post-intervention)WOMAC pain (post-intervention)Pain on walking NRS (post-intervention)ASES pain (post-intervention and longest follow-up) | Pain NRS ASES function Brief Fear of Movement ScaleAQoL 2WOMAC function (longest follow-up)WOMAC pain (longest follow-up)Pain on walking (longest follow-up) |
| **Hughes 2006** | Lorig Self-Efficacy Scale (post-intervention and longest follow-up)WOMAC stiffness (post-intervention) | McAuley Barriers and Time Exercise Adherence Efficacy ScalesTimed stand6-minute distance walkWOMAC function WOMAC painWOMAC stiffness (longest follow-up)Geri-AIMS pain scale  |
| Kloek 2018 | No significant outcomes | HOOS/KOOSTimed Up and Go test Pain NRSTiredness NRSASES  |
| Krein 2013 | No significant outcomes | RMDQMOS pain-related functional interference scorePain NRSExercise Self-Regulatory Efficacy Scale FABQ PA subscale |
| Lang 2021 | No significant outcomes | ODIFABQBack condition Beliefs Questionnaire Physical Activity Self-Efficacy ScaleEQ-5D-5L |
| Meng 2011  | GPMQ* Action-orientated coping (longest follow-up)
* Cognitive restructuring (longest follow-up)
* Mental distraction (longest follow-up)
 | Back posture habitsBack exercisesGPMQ* Subjective coping competence
* Counter activities
* Relaxation
 |
| Nelligan 2021 | Pain NRS (post-intervention)WOMAC function (post-intervention)KOOS pain (post-intervention)KOOS sport and recreation (post-intervention)AQoL (post-intervention)ASES pain (post-intervention) | ASES function Self-efficacy exercise |
| **Pisters 2010** | No other outcomes | No other outcomes |
| Schaller 2017 | No significant outcomes  | SF-36 pain  |
| Semrau 2021 | No significant outcomes | HFAQPain NRSSF-12Patient Health Questionnaire – Depression General Anxiety DisorderPerceived Stress ScaleTampa Scale of Kinesiophobia  |
| **Wallis 2017** | 40m walk test (post-intervention)Odds of lowering of systolic blood pressure below 140mmHg (post-intervention) | Pain NRSCardiovascular risk factors* Blood pressure
* Body mass index
* Waist circumference
* Fasting glucose levels
* Cholesterol
* Triglycerides

WOMAC 30 second chair stand test EQ-5DEQ-VASMedication use |
| Zacharia 2018 | Between group difference not reported | Between group difference not reported |
| Key: ASES = Arthritis Self-Efficacy Scale; AQoL = Assessment of Quality of Life; BPI = Brief Pain Inventory; EQ = EuroQol; FABQ = Fear Avoidance Beliefs Questionnaire; GERI-AIMS = Arthritis Impact Measurement Scales for the elderly; GPMQ = German Pain Management Questionnaire; GROC = Global Rating Of Change; HADS = Hospital Anxiety and Depression Scale; HFAQ = Hanover Functional Ability Questionnaire; HOOS = Hip disability and Osteoarthritis Outcome Score; KOOS = Knee injury and Osteoarthritis Outcome Score; MOS = Medical Outcomes Study; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; RMDQ = Roland Morris Disability Questionnaire; SF = Short-Form; SPPB = Short Physical Performance Battery; VAS = Visual Analogue Scale; WOMAC = Western Ontario and McMaster Universities Osteoarthritis IndexBold study name = significant (p < 0.05) for PA or sedentary behaviour outcomes at immediate post-intervention and/or longer-term follow-up |

Health-related outcomes in each category and studies with significant results in each category

|  |  |  |  |
| --- | --- | --- | --- |
| Outcome measure category | Outcome measures included in category | N studies assessing  | Studies with Significant outcomes (p<0.05) |
| Pain | WOMAC painPain VASPain NRSGROC pain BPI HOOS/KOOS painGeri-AIMS pain scale | 16 | Total: 5 (31.25%)Study name (measurement point): * Cederbom 2019 (post-intervention and longest follow-up)
* **Chen 2020 (post-intervention)**
* Hinman 2007 (post-intervention)
* **Hinman 2020 (post-intervention)**
* **Nelligan 2021 (post-intervention)**
 |
| Function | ODIWOMAC functionWOMAC stiffnessHFAQGROC functionHOOS/KOOS function HOOS/KOOS other symptomsRMDQBPI disabilityTiredness NRS | 18 | Total: 9 (50%)Study name (measurement point): * **Barone Gibbs 2018 (post-intervention)**
* Basler 2007 (longest follow-up)
* **Bennell 2017 (post-intervention and longest follow-up)**
* Cederbom 2019 (post-intervention)
* **Chen 2020 (post-intervention)**
* Hinman 2007 (post-intervention)
* **Hinman 2020 (post-intervention)**
* **Hughes 2006 (post-intervention)**
* Nelligan 2021 (post-intervention)
 |
| Psychological | Task specific self-efficacyASESMulti-dimensional Health Locus of Control ScaleCatastrophizing thoughts 2 itemFalls Efficacy Scale - InternationalExercise self-efficacy scaleDecisional Balance Scale for ExerciseLorig Self-Efficacy ScaleMcAuley Barriers and Time Exercise Adherence Efficacy ScalesExercise Self-Regulatory Efficacy Scale FABQ Brief Fear of Movement ScaleGPMQBack posture habitsBack exercisesHADS anxietyHADS depressionBack condition Beliefs QuestionnairePhysical Activity Self-Efficacy ScaleSelf-efficacy exercisePatient Health Questionnaire – Depression General Anxiety DisorderPerceived Stress ScaleTampa Scale of Kinesiophobia | 12 | Total: 7 (58.3%)Study name (measurement point): * Bieler 2017 (post-intervention - NW group)
* Bossen 2013 (longest follow-up)
* **Chen 2020 (post-intervention)**
* **Hinman 2020 (post-intervention and longest follow-up)**
* **Hughes 2006 (post-intervention and longest follow-up)**
* Meng 2011 (longest follow-up)
* Nelligan (post-intervention)
 |
| Quality of life (QOL) | SF-36SF-12HOOS/KOOS QOLAQoLAQoL llEQ-5DEQ-VASMOS | 12 | Total: 4 (33.33%)Study name (measurement point): * Bieler 2017 (post-intervention)
* Cederbom 2019 (post-intervention)
* Hinman 2007 (post-intervention)
* Nelligan 2021 (post-intervention)
 |
| Physical/functional performance  | Timed Up and Go Repeated chair stand/repeated sit-to-standStair climbQuadriceps strengthHamstring strength50-foot walk test Unloaded/loaded reach testSpine range of movement (ultrasound topometry)8-foot up and go test6-minute walk test Five Time Sit-to-Stand TestStep testHip abductor strengthTime stand 40m walk testSPPB | 9 | Total: 4 (44%)Study name (measurement point): * Bieler 2017 (post-intervention)
* **Chen 2020 (post-intervention)**
* Hinman 2007 (post-intervention)
* **Wallis 2017 (post-intervention)**
 |
| Cardiovascular health and risk factors  | Blood pressure Body mass indexWaist circumferenceFasting glucose levelCholesterolTriglycerides | 1 | Total: 1 (100%)Study name (measurement point): * **Wallis 2017 (post-intervention)**
 |
| Medication use | Medication use | 1 | Total: 0 (0%) |
| Key: ASES = Arthritis Self-Efficacy Scale; AQoL = Assessment of Quality of Life; BPI = Brief Pain Inventory; EQ = EuroQol; FABQ = Fear Avoidance Beliefs Questionnaire; GERI-AIMS = Arthritis Impact Measurement Scales for the elderly; GPMQ = German Pain Management Questionnaire; GROC = Global Rating Of Change; HADS = Hospital Anxiety and Depression Scale; HFAQ = Hanover Functional Ability Questionnaire; HOOS = Hip disability and Osteoarthritis Outcome Score; KOOS = Knee injury and Osteoarthritis Outcome Score; MOS = Medical Outcomes Study; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; RMDQ = Roland Morris Disability Questionnaire; SF = Short-Form; SPPB = Short Physical Performance Battery; VAS = Visual Analogue Scale; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.Bold study name = significant (p < 0.05) for PA or sedentary behaviour outcomes at immediate post-intervention and/or longest follow-up. |

Deviations from protocol

|  |  |  |
| --- | --- | --- |
| **Deviation from protocol** | **Reason why change made**  | **Effect on results**  |
| Hedge’s g effect measure used instead of Cohen’s d | Hedge’s g removes small sample bias that occurs with Cohen’s d. Due to some studies having small sample sizes, Hedge’s g was the preferred effect estimate | Using Hedge’s g may have slightly reduced the effect estimate due to removal of small sample biashttps://www.meta-analysis.com/downloads/Meta-analysis%20Effect%20sizes%20based%20on%20means.pdf  |
| Search did not include clinic trials registries | It was unnecessary to search the clinical trials registries as CENTRAL includes records from clinicaltrials.gov and WHO’s International Clinical Trials Registry Platform.  | No effect  |
| Moderators for meta-regression were not specified a-priori | We decided after data extraction to perform meta-regressions on number of BCTs and number of sessions in the interventions due to the large variations in these numbers. We wanted to assess whether higher numbers of these moderated the effect sizes | No effect – provided additional results, but did not effect main study results  |
| Report which BCTs were used to support behaviour change at different time-points | Most included studies did not alter their BCTs used for different time-points e.g. they did not use different BCTs for PA uptake or PA maintenance, so we would not have been able to make meaningful conclusions from this approach. We opted to analyse BCTs for their presence at any time-point in the intervention.  | Unable to determine which BCTs might have been more helpful to facilitate initial uptake of PA/reduction of SB and which may have been more helpful in supporting maintenance.  |
| Did not do a subgroup analysis for different locations of pain | Due to heterogeneity in the interventions, we did not feel this would have been a meaningful subgroup.  | No effect |
| Did a subgroup analysis with variations of the nature of interventions | Due to variations in interventions, we did an additional subgroup analysis grouping interventions into PA + counselling/coaching, PA + education, PA + education and counselling, and PA only. | No effect on main results. Provides additional insight into what interventions may be more effective.  |

**Figures:**

Figure: PA post-intervention funnel plot



Figure: PA longest follow-up funnel plot



Data used for meta-analysis