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, 9.1  NW: 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/reframing  Key: BCT = behaviour change technique | | |

Health-related (secondary) outcomes in each study

|  |  |  |
| --- | --- | --- |
| **Study** | **Significant outcomes (Time point)** | **Non-significant outcomes** |
| Baker 2020 | No significant outcomes | WOMAC  Timed Up and Go test  Repeated chair stand  Stair climb  Strength - Quadriceps  Strength – hamstrings |
| **Barone Gibbs 2018** | ODI (post-intervention) | Pain VAS  50-foot walk test  Repeated 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 VAS  WOMAC function |
| **Bennell 2017** | GROC function (Immediate Post-intervention and longest follow-up) | WOMAC  Pain NRS – overall  Pain NRS – walking  AQoL ll  GROC pain |
| Bieler 2017 | Timed stair climbing test (post-intervention) NW-control  8-foot Up and Go test (post-intervention) NW-control  MOS (post-intervention) NW-control  6-minute walk test (post-intervention) NW-control  Task-specific self-efficacy (post-intervention) NW-control  SF-36 role-physical (post-intervention) NW-control and ST-control  SF-36 vitality (post-intervention) NW-control  SF-36 mental health (post-intervention) NW-control | WOMAC  Task specific self-efficacy (ST-control)  ASES  SF-36 other scales and other interventions  Chair stand performance  Timed 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/KOOS  Pain NRS  Tiredness NRS  Multi-dimensional Health Locus of Control Scale  HADS 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)  SPPB  Catastrophizing thoughts 2 item  Falls Efficacy Scale - International  SF-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 Scale  AQoL 2  WOMAC 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 Scales  Timed stand  6-minute distance walk  WOMAC function  WOMAC pain  WOMAC stiffness (longest follow-up)  Geri-AIMS pain scale |
| Kloek 2018 | No significant outcomes | HOOS/KOOS  Timed Up and Go test  Pain NRS  Tiredness NRS  ASES |
| Krein 2013 | No significant outcomes | RMDQ  MOS pain-related functional interference score  Pain NRS  Exercise Self-Regulatory Efficacy Scale  FABQ PA subscale |
| Lang 2021 | No significant outcomes | ODI  FABQ  Back condition Beliefs Questionnaire  Physical Activity Self-Efficacy Scale  EQ-5D-5L |
| Meng 2011 | GPMQ   * Action-orientated coping (longest follow-up) * Cognitive restructuring (longest follow-up) * Mental distraction (longest follow-up) | Back posture habits  Back exercises  GPMQ   * 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 | HFAQ  Pain NRS  SF-12  Patient Health Questionnaire – Depression  General Anxiety Disorder  Perceived Stress Scale  Tampa Scale of Kinesiophobia |
| **Wallis 2017** | 40m walk test (post-intervention)  Odds of lowering of systolic blood pressure below 140mmHg (post-intervention) | Pain NRS  Cardiovascular risk factors   * Blood pressure * Body mass index * Waist circumference * Fasting glucose levels * Cholesterol * Triglycerides   WOMAC  30 second chair stand test  EQ-5D  EQ-VAS  Medication 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 Index  Bold 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 pain  Pain VAS  Pain NRS  GROC pain  BPI  HOOS/KOOS pain  Geri-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 | ODI  WOMAC function  WOMAC stiffness  HFAQ  GROC function  HOOS/KOOS function  HOOS/KOOS other symptoms  RMDQ  BPI disability  Tiredness 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-efficacy  ASES  Multi-dimensional Health Locus of Control Scale  Catastrophizing thoughts 2 item  Falls Efficacy Scale - International  Exercise self-efficacy scale  Decisional Balance Scale for Exercise  Lorig Self-Efficacy Scale  McAuley Barriers and Time Exercise Adherence Efficacy Scales  Exercise Self-Regulatory Efficacy Scale  FABQ  Brief Fear of Movement Scale  GPMQ  Back posture habits  Back exercises  HADS anxiety  HADS depression  Back condition Beliefs Questionnaire  Physical Activity Self-Efficacy Scale  Self-efficacy exercise  Patient Health Questionnaire – Depression  General Anxiety Disorder  Perceived Stress Scale  Tampa 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-36  SF-12  HOOS/KOOS QOL  AQoL  AQoL ll  EQ-5D  EQ-VAS  MOS | 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-stand  Stair climb  Quadriceps strength  Hamstring strength  50-foot walk test  Unloaded/loaded reach test  Spine range of movement (ultrasound topometry)  8-foot up and go test  6-minute walk test  Five Time Sit-to-Stand Test  Step test  Hip abductor strength  Time stand  40m walk test  SPPB | 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 index  Waist circumference  Fasting glucose level  Cholesterol  Triglycerides | 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 bias  https://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