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1       **Abstract**

2       **Purpose:** Exercise (planned, structured, repetitive movement) improves pain and function in  
3       people with persistent musculoskeletal pain (PMSK) but adherence is often poor. This  
4       systematic review evaluates the evidence from randomised controlled trials (RCTs) on the  
5       effectiveness of interventions to improve exercise adherence in people with PMSK and  
6       describes the content, context, and theoretical underpinning of behaviour change  
7       interventions designed to increase adherence.

8       **Methods:** Nine electronic databases were searched from inception dates to August 2017.  
9       Studies were included if they were: RCTs which included adults with PMSK  $\geq$ three months;  
10       $\geq$ one measure of exercise adherence, exercise prescribed to both groups and employed  $\geq$ one  
11      behaviour change technique (BCT) in the treatment group. Independent data extraction,  
12      theory coding, BCT taxonomy coding and quality assessment using Cochrane Risk of Bias  
13      (RoB) tool was conducted by two reviewers.

14      **Results:** Eight RCTs (five low, three high RoB) met inclusion criteria. Five trials reported  
15      between group differences in exercise adherence, favouring the treatment group. Three trials  
16      reported theoretical underpinning. There was moderate evidence that five BCTs: social  
17      support, goal setting, instruction of behaviour, demonstration of behaviour, practice/rehearsal  
18      improved exercise adherence. Interventions employing  $\leq$ seven BCTs, unique to those  
19      included in the control group, were most effective at enhancing exercise adherence.

20      **Conclusions:** Limited moderate quality evidence supports using a small number of BCTs to  
21      enhance exercise adherence in people with PMSK. Further research should explore the  
22      associations and synergies between BCTs and explicitly report how theory was utilized. This  
23      may inform recommendations for healthcare professionals working with this population.

## 24 **Introduction**

25 Persistent musculoskeletal pain (PMSK) is defined as pain of the axial skeleton that persists  
26 longer than expected after onset, usually for at least three months duration (Clinical Standards  
27 Advisory Group, 2000). Common diagnoses include low back pain, osteoarthritis and  
28 fibromyalgia (Dieppe, 2012). PMSK conditions are challenging to manage and have high  
29 personal, health and socioeconomic costs (Reid et al., 2011).

30 People with PMSK are often referred to a healthcare professional (HCP) and  
31 prescribed exercise or physical activity for treatment or management of their pain (World  
32 Health Organization, 2018). Exercise is defined as planned, structured and repetitive bodily  
33 movement done to improve or maintain physical fitness (Caspersen, Powell, & Christenson,  
34 1985); while physical activity (PA) is any bodily movement that results in energy expenditure  
35 (Caspersen et al., 1985). Interventions prescribing exercise or PA improve pain, function and  
36 quality of life in individuals with PMSK, including individuals with low back pain (UK  
37 Beam, 2004), lower extremity osteoarthritis (Bearne, Walsh, Jessep, & Hurley, 2011) and  
38 fibromyalgia (O'Connor et al., 2015). However, the majority of people with PMSK do not  
39 experience the benefits of exercise due to poor adherence to their prescribed programme  
40 (Peek, Sanson-Fisher, Mackenzie, & Carey, 2016). Treatment adherence has been defined as  
41 observing the behaviour endorsed by a HCP for the recommended duration (World Health  
42 Organization, 2003) and has been explored in similar health behaviours, such as medication  
43 adherence (Osterberg & Blaschke, 2005). However, due to the complexity of health  
44 behaviours, the findings from one behavioural domain cannot be easily transferred to another  
45 (Bartholomew et al., 2016). Factors influencing adherence may vary depending on the type of  
46 behaviour being assessed (Jack, McLean, Klaber, & Gardiner, 2010). It is therefore crucial to  
47 be explicit about the behaviour being measured and to distinguish between exercise and PA  
48 behaviour. Despite evidence that lifestyle PA, such as walking, improves outcomes (O'Connor

49 et al., 2015), current clinical guidelines prioritise the use of exercise programmes for the  
50 management of PMSK conditions (Busch et al., 2011; National Institute of Health and Care  
51 Excellence, 2016). Therefore, this review focuses on adherence to prescribed exercise.

52 Evidence suggests that exercise behaviours are modifiable and behaviour initiation  
53 and maintenance may be enhanced with behaviour change interventions (Ben-Ami, Chodick,  
54 Mirovsky, Pincus, & Shapiro, 2017; Michie, Abraham, Whittington, Mcateer, & Gupta,  
55 2009). However, the factors driving the initiation of a behaviour differ from those  
56 contributing to its maintenance (Rothman, 2000). Exercise adherence may encompass both  
57 the initiation and maintenance of the behaviour. In this review, the term ‘exercise adherence’  
58 will therefore encompass both of those behaviours.

59 The identification of behaviour change techniques (BCTs) may inform the  
60 development of a behaviour change intervention and recommendations for HCPs working  
61 with this population. A taxonomy identified 93 BCTs as the active components in  
62 interventions designed to change behaviour (Michie et al., 2013) in order to aid the  
63 development, reporting and replication of interventions. In addition, the context within which  
64 the BCTs are delivered may also influence effectiveness. For instance, who delivers an  
65 intervention, how much training they have received to deliver the intervention, the patient-  
66 provider relationship and the environment all should be explored when assessing the  
67 effectiveness of behaviour change interventions (Davidson et al., 2003; Drahota et al., 2012).  
68 These factors should be reported in the description of trials to aid in intervention replication,  
69 and allow comparisons and conclusions to be drawn between interventions (Hoffmann et al.,  
70 2014). The Template for Intervention Description and Replication checklist (TIDieR;  
71 Hoffmann et al., 2014) has been developed to guide description of interventions.

72 The TIDieR checklist prompts the reporting of theory to provide rationale for the  
73 study protocol. The use of theory is recognized by the Medical Research Council as the first

74 step in the development of complex interventions (Craig et al., 2013). There is increasing  
75 evidence that interventions developed with a theoretical foundation are more effective than  
76 interventions without an explicit theoretical underpinning (Glanz, 2015; Prestwich et al.,  
77 2014). Nevertheless, there remains conflicting evidence regarding the efficacy of the use of  
78 theory to underpin intervention effectiveness and so further research is required (Gourlan et  
79 al., 2014; Noar, Benac, & Harris, 2007).

80 Research into exercise adherence in people with PMSK has been hampered by a lack  
81 of standardised outcome measures (Beinart, Goodchild, Weinman, Ayis, & Godfrey, 2013;  
82 Geneen et al., 2017). This results in heterogeneous outcome data which limits the ability to  
83 compare interventions. Despite this, previous reviews have explored the effectiveness of  
84 interventions to improve adherence to prescribed exercise and physiotherapy programmes  
85 (Jordan, Holden, Mason, & Foster, 2010; Peek et al., 2016), as well as the use of BCTs in  
86 group based self-management programmes (Keogh, Tully, Matthews, & Hurley, 2015). These  
87 reviews have suggested that behaviour change interventions may be effective in improving  
88 exercise adherence. However, they do not explicitly identify and compare the components of  
89 interventions targeting exercise adherence in people with PMSK. This review evaluated the  
90 evidence from randomised controlled trials (RCTs) about the effectiveness of the content and  
91 context of behaviour change interventions aimed at increasing adherence to prescribed  
92 exercise in people with PMSK.

### 93 ***Objectives***

94 This systematic review had three objectives: (i) to describe the content (by coding BCTs) and  
95 context (informed by the TIDieR framework) used in behaviour change interventions to  
96 enhance adherence to prescribed exercise, (ii) to evaluate the effectiveness of BCTs  
97 associated with increased adherence and the context in which they were delivered, (iii) to  
98 identify the role of theory in these interventions.

## 99 **Methods**

### 100 *Protocol and registration*

101 The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)  
102 guidelines were followed (Moher, Liberati, Tetzlaff, Altman, & the PRISMA group, 2009)  
103 and a checklist is available in supplement one. The review protocol is registered on  
104 PROSPERO (CRD42016049907) and can be accessed  
105 from [http://www.crd.york.ac.uk/PROSPERO/display\\_record.asp?ID=CRD42016049907](http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016049907).

### 106 *Eligibility criteria*

107 RCTs were included in this review if they investigated participants aged 18-65 years. There is  
108 an increased risk of comorbidities, particularly serious pathology, which may affect the  
109 management of older adults (Greenhalgh, 2006), and the age range selected for this review  
110 reflects the range used in global PA guidelines (World Health Organization, 2011). Trials  
111 including older or younger participants (ie <18 or >65 years) were included if 80% of  
112 participants were between 18-65 years. Participants must have been diagnosed by a HCP with  
113 musculoskeletal pain persisting for three months or longer. Musculoskeletal pain was defined  
114 as any condition of the axial skeleton (cervical, thoracic or lumbar spine) or any peripheral  
115 joints (adapted from Dieppe, 2012). Treatment groups must have received at least one BCT,  
116 defined as any effort by the HCP or researchers to change, or support change, of a behaviour.  
117 These may include, but were not limited to, goal setting activities or behaviour monitoring.  
118 The trial must have included a specific, measurable prescription of exercise (i.e. a set of  
119 planned, structured and repetitive movements to be followed for the duration of the  
120 intervention). Outcome measures must have included a measure of adherence (defined by the  
121 original authors) to the prescribed exercise programme.

122 Exclusion criteria included (i) trials that only investigated youth and adolescents <18  
123 years or adults aged over 65 years; (ii) people diagnosed with inflammatory conditions (e.g.

124 rheumatoid arthritis); (iii) control groups including healthy controls, inpatient populations or  
125 surgical waiting list patients.

### 126 ***Information sources***

127 Electronic databases were searched by one researcher (L.M) for published (CINAHL,  
128 PsychINFO, Embase, MEDLINE and the Cochrane Central Register of Controlled Trials) and  
129 unpublished (openDOAR, OpenGrey, Web of Science and Ethos) English language trials  
130 from their inception dates to 22<sup>nd</sup> August 2017. The search used combined terms for chronic  
131 pain AND behaviour therapy AND exercise and their appropriate MeSH terms (see  
132 supplement two for tailored search strategy and all MeSH terms). Search terms were informed  
133 by other reviews on chronic/persistent musculoskeletal pain (Hall et al., 2015; Jordan et al.,  
134 2010) and health behaviour change (Galea, Weinman, White, & Bearne, 2013; Keogh et al.,  
135 2015). The terms PA, exercise and physical fitness are often used interchangeably, therefore  
136 all terms were searched in the databases to ensure comprehensiveness. However, regardless of  
137 the term used by study authors, only trials meeting the definition for exercise as defined above  
138 were included. Secondly, reference lists of included trials were hand searched. Following  
139 removal of duplicates, two reviewers (L.M., L.S.) independently screened the titles and  
140 abstracts of potentially relevant trials. Full text screening was then conducted by the two  
141 reviewers. A third reviewer (E.G.) was available to act as arbiter but was not required.

### 142 ***Study selection and data extraction***

143 Data were independently extracted by two reviewers (L.M., L.S.). Information about  
144 theoretical constructs and BCTs included in the treatment and control groups were extracted  
145 in addition to the standardized information on study design, participant characteristics, and  
146 outcomes (such as measure and duration of adherence). Where insufficient information was  
147 reported, authors were contacted for further details.

148 ***Risk of bias of individual studies and level of evidence***

149 Individual trials were assessed using the Cochrane Risk of Bias Scale (J. Higgins & Green,  
150 2011). The risk of bias (RoB) tool assesses trials across six bias domains (selection,  
151 performance, detection, attrition, reporting and any other biases detected) and scores each  
152 domain as either high, low, or unclear RoB. However, due to the nature of the included  
153 studies, it was difficult to blind participants and the personnel delivering the intervention  
154 (Larkin et al., 2015; van Tulder et al., 2001). Therefore, this domain was not included in the  
155 final RoB score. In the case of a lack of description of study procedure, it was assumed the  
156 task was not carried out and therefore rated as high RoB.

157 Study quality ratings were determined following thresholds used previously (Bearne,  
158 Byrne, Segrave, & White, 2016). RoB was evaluated as high RoB in the presence of three or  
159 more sources, or unclear sources of bias, and low RoB if there was evidence for the presence  
160 of less than three sources of bias.

161 ***Analysis***

162 To assess the content of the interventions, two reviewers (L.M, S.A) coded the BCTs  
163 used in the treatment and control groups using the Behaviour Change Taxonomy v1 (Michie  
164 et al., 2013). Both reviewers completed the online BCT version one training in recognizing  
165 and coding BCTs prior to coding. Past research has shown that control groups often  
166 incorporate BCTs and the nature of the control group can influence study findings (Bishop,  
167 Fenge-Davies, Kirby, & Geraghty, 2015). Therefore, BCTs were extracted from both the  
168 treatment and control groups. In the case of multiple treatment arms, BCTs were assessed  
169 separately between arms and compared with the control group. The effectiveness of each BCT  
170 (in treatment or control group) in enhancing exercise adherence was calculated using a rating  
171 system based on the level of evidence following the recommendations of the Cochrane Back  
172 Group (van Tulder, Furlan, Bombardier, & Bouter, 2003):



- |                                |  |
|--------------------------------|--|
| <b>1.Strong evidence</b>       | Consistent findings in multiple high-quality trials                              |
| <b>2.Moderate evidence</b>     | Consistent findings in multiple low-quality trials and/or one high-quality trial |
| <b>3. Limited evidence</b>     | One low-quality trial  |
| <b>4. Conflicting evidence</b> | Inconsistent findings in multiple trials   |

173 To assess the application of theory in the development and evaluation of the behaviour  
174 change interventions, trials were coded using the 19 item Theory Coding Scheme (TCS;  
175 (Michie & Prestwich, 2010). To test the extent to which theory was used in intervention  
176 design, composite scores using the TCS were created (Prestwich et al., 2014; Webb, Joseph,  
177 Yardley, & Michie, 2010). Higher scores (with a range from 0-2) indicate stronger theoretical  
178 integration in study design. The first score reflects the extent to which each BCT was linked  
179 to a theory-relevant construct (items 7-9 in TCS). The second method measures the extent to  
180 which the constructs within theory were targeted by BCTs (items 9-11 in TCS). Lastly, an  
181 overall theory score was computed, reflecting the use of TCS items that relate to using theory  
182 to develop the intervention. This was done by combining the score of the use of theory in  
183 developing intervention techniques (TCS 5) with the first two composite scores (Prestwich et  
184 al., 2014; Webb et al., 2010).

185 The contextual aspects of the interventions were extracted following the TIDieR  
186 checklist (Hoffmann et al., 2014). This included who delivered the intervention, mode of  
187 delivery (e.g. if it was delivered face to face) and where it was delivered.

## 188 **Results**

189 Due to the heterogeneity in intervention design and outcome reporting, conducting a meta-  
190 analysis was not possible. The results are summarised qualitatively and presented as a  
191 narrative synthesis, following the guidance of Popay and colleagues (2006). As a result of the  
192 limited amount of empirical evidence in this field, all trials identified as meeting search  
193 criteria are included in the synthesis of results.

194 ***Selection process***

195 A total of 1,943 manuscripts were identified from published, peer-reviewed journals. No  
196 unpublished studies were identified. Four additional studies were identified through hand  
197 searching relevant reference lists. Following the removal of 451 duplicates, 1,492 titles and  
198 abstracts were screened and 77 full texts were identified for full screening, of which eight  
199 trials met the inclusion criteria (Figure 1).

200 [Insert Figure 1 Here]

201 ***Study characteristics and participants***

202 Eight randomized controlled trials were included in this review (Coppack, Kristensen, &  
203 Karageorghis, 2012; Friedrich, Gittler, Halberstadt, Cermak, & Heiller, 1998; Friedrich,  
204 Gittler, Arendasy, & Friedrich, 2005; Harkapaa, Mellin, Jarvikoski, & Hurri, 1990; Harkapaa,  
205 Jarvikoski, Mellin, Hurri, & Luoma, 1991; Huyser, Buckelew, Hewett, & Johnson, 1997;  
206 Linton, Hellsing, & Bergstrom, 1996; Peterson et al., 2015; Reilly, Lovejoy, Williams, &  
207 Roth, 1989; Vong, Cheing, Chan, So, & Chan, 2011) (Table 1). Study sample sizes ranged  
208 from 40 to 459 participants, totalling 1,018 participants. All participants in the included trials  
209 were aged between 18-65 years. Trials were conducted in: United States (Huyser et al., 1997;  
210 Reilly et al., 1989), China (Vong et al., 2011), United Kingdom (Coppack et al., 2012),  
211 Sweden (Linton et al., 1996; Peterson et al., 2015), Austria (Friedrich et al., 1998) and  
212 Finland (Harkapaa et al., 1990). Six trials included participants with persistent low back pain  
213 (Coppack et al., 2012; Friedrich et al., 1998; Harkapaa et al., 1990; Linton et al., 1996; Reilly  
214 et al., 1989; Vong et al., 2011), while the remaining two investigated participants with  
215 fibromyalgia (Huyser et al., 1997) or whiplash disorders (Peterson et al., 2015). Mean  
216 duration of pain symptoms reported ranged from 1.6 years (Peterson et al., 2015) to 14.6  
217 years (Harkapaa et al., 1990). The definition of adherent behaviour differed across trials, and  
218 measures of adherence consisted of: diaries/exercise logs (Friedrich et al., 1998; Linton et al.,

1996; Vong et al., 2011), questionnaires (Coppack et al., 2012; Huyser et al., 1997), or number of exercise sessions completed (Harkapaa et al., 1990; Reilly et al., 1989). Length of follow up ranged from 15 days (Coppack et al., 2012) to five years (Friedrich et al., 2005).

[Insert Table 1 Here]

### ***Risk of bias***

The summary of the RoB assessment can be found in Table 2. The two reviewers (L.M., L.S.) had good agreement and any discrepancies were resolved following discussion. Five studies were assessed as low RoB (Coppack et al., 2012; Friedrich et al., 1998; Huyser et al., 1997; Peterson et al., 2015; Vong et al., 2011), and three as high RoB (Harkapaa et al., 1990; Linton et al., 1996; Reilly et al., 1989).

[Insert Table 2 Here]

### ***Content of the interventions***

Five of the eight included trials reported greater between group adherence favouring the treatment groups (Coppack et al., 2012; Harkapaa et al., 1990; Linton et al., 1996; Reilly et al., 1989; Vong et al., 2011). The standardized mean difference was calculated and presented where possible in Table 1 (forest plot in supplement three). Three of the five trials reporting significant between group differences were considered to be high RoB (Harkapaa et al., 1990; Linton et al., 1996; Reilly et al., 1989), while the non-significant differences were all found in low RoB trials (Friedrich et al., 1998; Huyser et al., 1997; Peterson et al., 2015).

There was good BCT coding agreement between reviewers for treatment groups (75.3%) and control groups (71.6%). Overall, there were 30 different BCTs (out of a possible 93) identified in the eight trials (Table 3). The number of BCTs varied from three to eleven (median 7) in the treatment group and one to six (median 3.5) in the control group. *Instruction on how to perform behaviour, demonstration of behaviour* and *behaviour practice/rehearsal* were the most commonly employed BCTs. In the treatment group, these three BCTs were

244 observed in 6/8, 5/8 and 5/8 trials respectively. In the control group, they were observed in  
245 7/8, 4/8, and 5/8 trials respectively.

246 Based on the Cochrane Back Group rating system (van Tulder et al., 2003) none of the  
247 BCTs produced strong evidence for their effectiveness in enhancing exercise adherence.  
248 There was evidence that *social support (unspecified)*, *goal setting (behaviour)*, *instruction of*  
249 *behaviour*, *demonstration of behaviour* and *behaviour practice/rehearsal* were moderately  
250 effective at enhancing exercise adherence (see article by Michie et al., 2013 for full  
251 descriptions of these BCTs).

252 Two low RoB trials (Friedrich et al., 2005; Peterson et al., 2015) reporting non-  
253 significant between group difference in exercise adherence employed the most BCTs within  
254 the treatment groups (9-11 BCTs). Additionally, both the treatment and control groups in  
255 these two trials received three of the BCTs that had the greatest evidence of effectiveness to  
256 enhance exercise adherence (*instruction of behaviour*, *demonstration of behaviour*, and  
257 *behaviour practice/rehearsal*) potentially confounding intervention effectiveness.

258 Three high RoB trials measured adherence to exercise for six months or more. Reilly  
259 et al (1989) and Linton et al (1996) reported greater between group exercise adherence  
260 favouring the treatment group after six months and Harkapaa et al (1991) observed greater  
261 between group exercise adherence after 1.5 years. These trials employed seven or less BCTs  
262 in the treatment group and no more than two BCTs within the control group.

263 The content of the prescribed exercise programmes varied. All were tailored to the  
264 participant and delivered face to face by a HCP. Three (two low, one high RoB) trials  
265 included varied exercise progressions based on either participant progress or preference  
266 (Coppack et al., 2012; Reilly et al., 1989; Vong et al., 2011) and reported significant between  
267 group adherence in the treatment group. Two trials (one low, one high RoB) involved group

268 training (Coppack et al., 2012; Harkapaa et al., 1990), and both reported greater adherence in  
269 treatment groups compared to control.

270 [Insert Table 3 here]

### 271 *Context of the interventions*

272 Three trials (Friedrich et al., 1998; Peterson et al., 2015; Vong et al., 2011), administered  
273 interventions solely by a physiotherapist/physical therapist, one trial (Huyser et al., 1997) by a  
274 physician, one trial (Linton et al., 1996) by a psychologist, one trial (Harkapaa et al., 1990) by  
275 a combination of all three, and two trials (Coppack et al., 2012; Reilly et al., 1989) were  
276 delivered by exercise specialists. No included trials provided specific detail regarding the  
277 training offered or completed by the HCPs.

278 Five low RoB trials delivered the behaviour change programme alongside the  
279 prescribed exercise programme in a clinic. Two trials reported greater adherence in the  
280 treatment groups (Coppack et al., 2012; Vong et al., 2011), while three trials (Friedrich et al.,  
281 1998; Huyser et al., 1997; Peterson et al., 2015) did not report a significant between group  
282 difference. Three trials (high RoB) delivered the behaviour change and exercise programme in  
283 a community health centre and reported greater between group adherence favouring the  
284 treatment group (Harkapaa et al., 1990; Linton et al., 1996; Reilly et al., 1989).

285 The five trials (two low, three high RoB) reporting significant between group  
286 difference delivered the interventions between two to seven days per week (Coppack et al.,  
287 2012; Harkapaa et al., 1990; Linton et al., 1996; Reilly et al., 1989; Vong et al., 2011). The  
288 duration of the sessions varied between 30 minutes (Coppack et al., 2012; Vong et al., 2011)  
289 to over two hours (Linton et al., 1996) (Table 3).

### 290 *Theoretical basis of included interventions*

291 Of the eight trials included, only three trials (two low, one high RoB) reported using theory to  
292 guide the intervention. Coppack et al (2012) scored the maximum TCS summary score of five

293 utilizing tenets of Personal Construct Theory (Kelly, 1963). Constructs of Health Locus of  
294 Control (Lefcourt, 1981) were reported by Harkapaa et al (1990), which scored a TCS  
295 summary score of three, and a combination of the Social Cognitive Theory (Bandura, 1986)  
296 and the Transtheoretical Model (Glanz, Rimer, Viswanath, & Orleans, 2008) informed the  
297 development of the intervention by Peterson et al. (2015) and scored a TCS summary score of  
298 two (see supplement four for full coding).

## 299 **Discussion**

300 To the authors' knowledge, this is the first systematic review to evaluate the content and  
301 context of behaviour change interventions administered to improve exercise adherence in  
302 people with PMSK. There is moderate quality evidence from two trials with low RoB  
303 (Coppack et al., 2012; Vong et al., 2011) and three with high RoB (Harkapaa et al., 1991;  
304 Linton et al., 1996; Reilly et al., 1989) that the inclusion of a behaviour change intervention  
305 incorporating BCTs enhances adherence to prescribed exercise compared to a control group.  
306 Furthermore, there is evidence to suggest that the type, amount, and delivery of BCTs will  
307 influence the level of adherence. Five BCTs were found to have a moderate level of evidence  
308 to support adherence including:

- 309 • Social support (unspecified)
- 310 • Goal setting (behaviour)
- 311 • Instruction of behaviour
- 312 • Demonstration of behaviour
- 313 • Behaviour practice/rehearsal

314 Trials implementing these BCTs within their treatment groups produced significant between  
315 group differences in favour of the treatment groups. Furthermore, the presence of these BCTs  
316 in the control group were associated with higher adherence rates in the control groups in three  
317 trials (Friedrich et al., 2005; Huyser et al., 1997; Peterson et al., 2015).

318           There is some evidence to suggest that trials employing seven or less BCTs have  
319 greater effectiveness than those employing more; the two trials (low RoB) employing the  
320 most BCTs to treatment groups found no significant between group difference in exercise  
321 adherence (Friedrich et al., 2005; Peterson et al., 2015). There is conflicting evidence within  
322 the literature regarding the optimum number of BCTs. Our findings concur with the findings  
323 of Michie et al (2009), who report that administering more BCTs did not result in higher PA  
324 levels. Conversely Bishop (2015) reported greater adherence in interventions with a higher  
325 number of BCTs. However, trials with control groups containing a low number of BCTs  
326 compared to the treatment group were associated with better outcomes, particularly if the  
327 control group contained unique BCTs from the treatment group (Bishop et al., 2015).  
328 Similarly, in our review the three trials (all assessed as high RoB) reporting the highest  
329 exercise adherence after six months had less than three BCTs within their control group  
330 (Harkapaa et al., 1991; Linton et al., 1996; Reilly et al., 1989). This suggests that the disparity  
331 between the number of BCTs used in the treatment and control groups may influence results.  
332 The possible cumulative or confounding effects of these BCTs should be investigated to  
333 further explore their influence (Michie et al., 2009). Furthermore, this may suggest that  
334 accurately and effectively delivering a small number of BCTs may be more important than  
335 administering numerous BCTs poorly. The use of BCTs to enhance adherence to treatment  
336 has increased (Spetch & Kolt, 2001), however the HCPs providing these treatments may not  
337 obtain formal training in BCT delivery (Arvinen-Barrow, Penny, Hemmings, & Corr, 2010),  
338 which is likely to be linked to their ability to deliver them well. There was a lack of detail  
339 reported regarding the amount of training provided for treatment delivery, or of any  
340 assessment of fidelity. This may call into question whether the behaviour change programmes  
341 were administered consistently or whether it is feasible for the healthcare professional to  
342 provide this type of treatment within their practice.

343 Our review found that many trials employed the same BCTs in both the treatment and  
344 control groups and reported no significant differences between the two groups. This suggests  
345 that study design may have influenced results, since monitoring BCTs delivered in usual care  
346 or in waiting list control groups can be challenging. This should be considered when  
347 designing future studies so that BCTs within control groups can be accurately recorded. The  
348 five trials reporting significant between group differences in exercise adherence investigated  
349 populations with persistent low back pain, however, there is no evidence to suggest that pain  
350 duration was related to adherence. HCPs, such as physiotherapists, should be aware of the  
351 value of including BCTs within practice, to initiate or maintain exercise adherence in people  
352 with PMSK, regardless of the duration of symptoms.

353 The type of exercise programme prescribed to participants varied across the trials. The  
354 trials producing a significant between group difference all implemented a progressive, graded  
355 exercise programme to the treatment group. Three trials reporting significant between group  
356 differences administered the programme in a community health club (Harkapaa et al., 1991;  
357 Linton et al., 1996; Reilly et al., 1989), and two trials produced significant between group  
358 differences with group exercise training (Coppack et al., 2012; Harkapaa et al., 1991). Based  
359 on the Hedonic Principle, people will maximise what feels good, and be driven by enjoyment  
360 and positive affect (E. T. Higgins, 2012). Enjoyment has been found to be a strong mediator  
361 of exercise adherence in people with musculoskeletal pain (Hagberg, Lindahl, Nyberg, &  
362 Hellénus, 2009). This review did not include trials that measured enjoyment but this provides  
363 some evidence that patients with pain conditions may have stronger adherence rates if they  
364 experience more tailored and varied exercise programmes. Additionally, given the  
365 effectiveness of group-based physiotherapy programmes on pain outcomes (O'Keeffe, Hayes,  
366 McCreesh, Purtill, & O'Sullivan, 2016), further research should explore the integration of the  
367 BCTs within group-based classes.



368 Participants in the treatment group had more behaviours to adhere to than those in the  
369 control groups, as they were asked to participate in both the behaviour change and the  
370 prescribed exercise programme. This could have been burdensome for the participants and the  
371 personnel delivering the intervention. There was heterogeneity in who administered the  
372 treatment, with minimal evidence to support one provider over the other. A viable programme  
373 that can be sustained by both patients and HCPs is required to enhance adherence in people  
374 with PMSK. Behaviour change interventions may benefit from paying attention to the mode  
375 of delivery and the context in which the content is delivered.

376 There is increasing evidence suggesting that interventions with a clear theoretical  
377 underpinning are more effective than those without, particularly in the health behaviour  
378 change literature (Glanz & Bishop, 2010). However, conflicting evidence persists within the  
379 literature and the current review. Only one intervention in this review explicitly used theory to  
380 inform both design and delivery. Furthermore, some of the included trials evaluated  
381 interventions which were not explicitly underpinned by theory and reported greater between  
382 group differences in exercise adherence favouring the treatment group. Due to these findings  
383 and the discrepancies within the literature, questions remain about whether a theoretical  
384 underpinning is associated with intervention effectiveness. There needs to be more accurate  
385 reporting of the use of theory to support interventions in order to assess whether it is a  
386 prerequisite for success.

### 387 *Methodological considerations*

388 There are limitations to this review that should be noted. Due to the small number of included  
389 trials and the fact that three of these had a high RoB, findings are tentative and must be  
390 treated with caution. It should be noted that the current findings only provide an indication of  
391 possible associations between the BCTs and intervention effectiveness and potential dose  
392 response relationships. None of the trials included in this review reported conducting an

393 intervention fidelity assessment, and so it is not known if the interventions, including the  
394 BCTs, were delivered consistently and as planned. This may have led to the inaccurate  
395 reporting and interpretation of results. Treatment fidelity assessments allow researchers to  
396 detect any deviations or errors in the trial design and implementation. Higher levels of  
397 treatment fidelity have been associated with better trial retention rates and treatment outcomes  
398 (Borrelli, 2011).

399         Within this review there is also the risk of inaccurate coding of the BCTs, especially  
400 when poor intervention reporting, or description, make some techniques difficult to classify.  
401 While this effect was minimised in the current review by ensuring consistent interpretation  
402 between the two coders, it highlights the need for better reporting in behaviour change  
403 literature. The National Institute for Health and Clinical Excellence (2007) guidelines  
404 recommend interventions are focused on those behaviours that need modifying. The measure  
405 of exercise adherence was often incidental to the overall study objectives, which may have  
406 affected the reporting of the intervention and impact on adherence levels.

407         The methods of reporting exercise adherence as an outcome varied across included  
408 trials, limiting comparisons and eliminating the option of conducting a meta-analysis. The  
409 included studies all used self-reported measures of exercise adherence that lacked  
410 standardisation. This may have led to inaccurate reporting of exercise levels due to recall or  
411 self-report bias (Prince et al., 2008). There is a lack of valid and reliable measures of exercise  
412 adherence (Beinart et al., 2013) and only a few have undergone psychometric testing (see  
413 Newman-Beinart et al., 2017). This highlights the need for standardized, validated measures  
414 to move the research forward.

415         Additionally, this review only included interventions with an exercise prescription,  
416 and not general PA. PA, such as walking (O'Connor et al., 2015) and habitual PA (Ben-Ami

417 et al., 2017), have been found to decrease pain in this population. Future reviews should  
418 further explore adherence to PA interventions in a population with PMSK.

419 ***Conclusion***

420 This review found that there was moderate evidence that five BCTs: social support, goal  
421 setting, instruction of behaviour, demonstration of behaviour, and behavioural  
422 practice/rehearsal improved exercise adherence in people with PMSK when compared to a  
423 control group. Treatment groups including seven or less BCTs, which were unique to any  
424 BCTs used in the control group, were most effective at enhancing exercise adherence. HCPs  
425 should consider incorporating BCTs into the prescription of exercise for people with PMSK  
426 and observed patterns could be used for hypothesis testing in future intervention development.  
427 This may aid progress in the field by gathering evidence informing what is delivered, by  
428 whom, and where it is best implemented.

429 **Conflicts**

430 No potential conflict of interest reported.

431

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629

Figure 1: PRISMA diagram

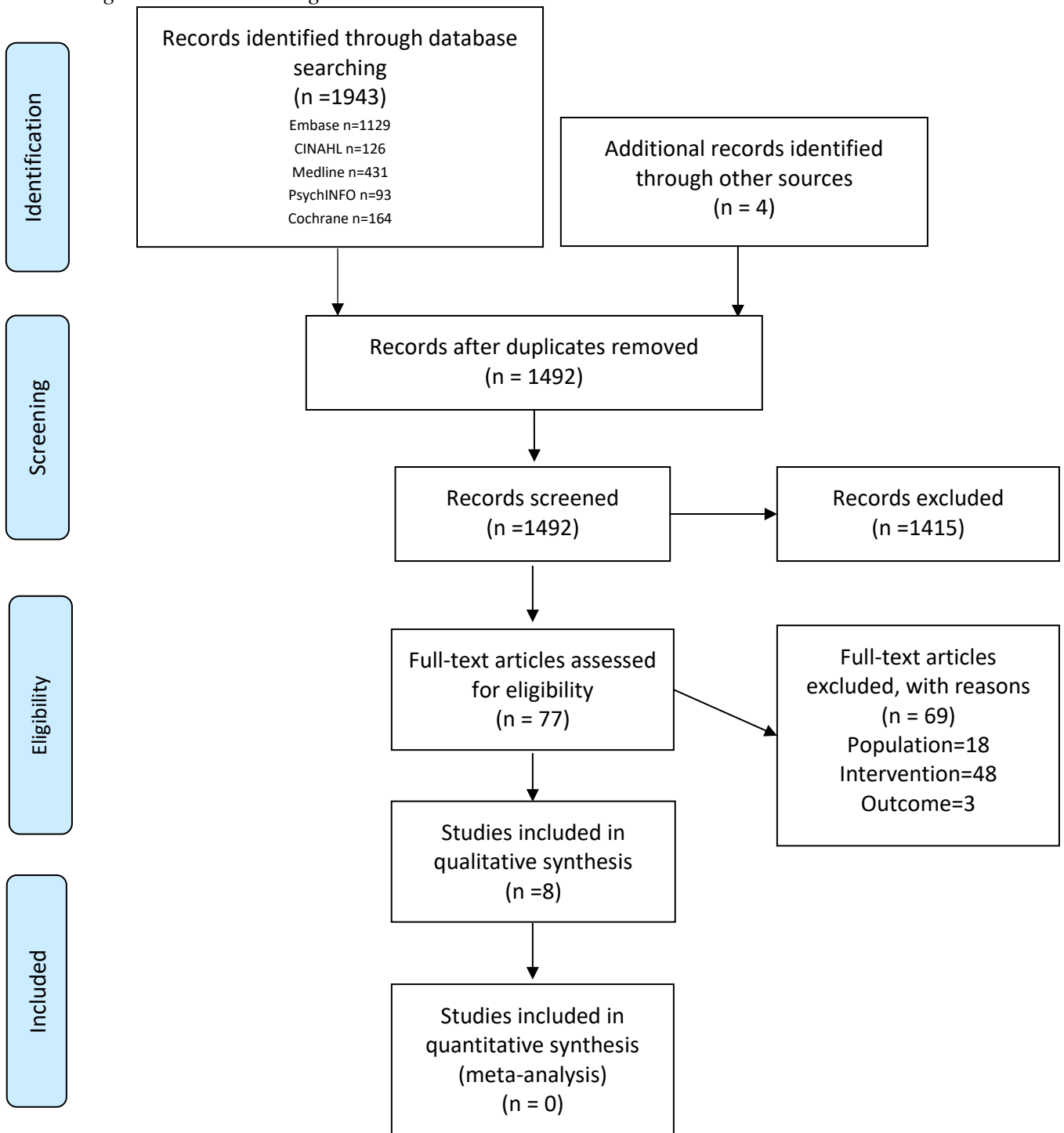


Table 1: Study characteristics

First author	Diagnosis	Pain duration (years) <sup>a</sup>		N (% Female)	Age <sup>a</sup>	Measure of Adherence <i>How adherence is calculated</i>	Length of follow up	Results <sup>a</sup>		
		Treatment	Control					Treatment	Control	Std. mean difference, random, 95% CI <sup>b</sup>
<b>Huyser (1997)</b>	Fibromyalgia	11.7 (9)	13.2 (9.4)	54 ( <i>not reported</i> )	44 (9.6)	Participant self-report (questionnaire)  <i>Number of weeks successfully completing exercise 3x/week (range 0-6)</i>	6 weeks	4 (1.5)	5 (1.5)	-0.66 [-1.21, -0.11]
<b>Vong (2011)</b>	Low back pain	3.5 (4.7)	4.3 (6)	76 (63)	45 (11.2)	Participant self-report (diary)  <i>Number of home exercise sessions/week</i>	1 month	12.9 (7.2)	5.8 (4.1) *	1.20 [0.71, 1.63]
<b>Coppack (2012)</b>	Low back pain	2.6 (0.3)		32 (6)	33 (7.9)	Sports Injury Rehab Scale (SIRAS)  <i>Max 15</i>	15 days	13.7 (1.6)	11.7 (1.3) *	1.34 [0.56, 2.11]
<b>Peterson (2015)</b>	Whiplash associated disorder	1.6 (0.7)	1.7 (0.7)	216 (66)	40 (11)	Physiotherapist and participant self-report (diary)  <i>% participants completing &gt;50% prescribed home exercise sessions</i>	6 months	53%	60%	Data not available
<b>Friedrich (1998,2005)</b>	Low back pain	4.2 (4.1)	3.8 (3.7)	93 (58)	43 (10.4)	Staff and participant self-report (diary)  <i>Years participating in prescribed exercises 3x/week</i>	5 years	3.5 (2)	4.4 (2.2)	-0.42 [-0.84, -0.01]

<b>Harkapaa (1990,1991)</b>	Low back pain	14.6 ( <i>not reported</i> )	13.4 ( <i>not reported</i> )	459 (37)	45 ( <i>not reported</i> )	Physician self-report (diary) <i>% participants performing faultless exercise</i>	1.5 years	51%	37% *	Data not available
<b>Reilly (1989)</b>	Low back pain	Not reported		40 (50)	Not reported	Gym staff report (diary) <i>Number of sessions attended during study</i>	6 months	90.8 (3.3)	31.9(17.2) *	4.66 [3.42, 5.9]
<b>Linton (1996)</b>	Low back pain	Not reported		48 (42)	42 ( <i>not reported</i> )	Participant self-report (diary) <i>% participants completing exercise 2x/week</i>	6 months	52%	27% *	Data not available

**a** Presented as M (*SD*) unless otherwise indicated

**b** Total 95 % CI 1.12 [-0.15, 2.39] Heterogeneity: Chi<sup>2</sup>=90.54, df =5 (P< 0.00001)

\* p >.05 between group difference



Table 2: Risk of bias of included studies

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Summary Score *
Coppack	+	+	+	+	+	Low
Friedrich	?	-	+	+	+	Low
Harkapaa	-	-	-	+	+	High
Huyser	?	-	+	+	+	Low
Linton	?	-	-	+	+	High
Peterson	+	+	+	+	+	Low
Reilly	-	-	-	+	+	High
Vong	+	+	+	+	+	Low

\*Summary bias score calculated as high where  $\geq 3$  sources or unclear and low where  $< 3$  RoB




 Low risk of bias  
  High risk of bias  
  Unknown risk of bias

Table 3: Intervention components

First author <i>Intervention</i>	Behaviour change programme				Exercise programme					Frequency of in-person sessions	Duration of in-person sessions
	BCTs in treatment group	BCTs in control group	Who delivered	Where	Tailored	Progressive	Supervised	Who delivered	Where		
<b>Huyser (1997)</b> <i>Biofeedback/relaxation</i>	(1.6), (2.6), (4.1), (6.1), (8.1), (12.6), (13.2)	(4.1), (6.1), (8.1)	Physician	Clinic	Yes	Not clear	No	Physician	At home	1x per week	2.5-3 hours
<b>Vong (2011) *</b> <i>Motivation enhancement</i>	(3.1), (9.1), (9.3)	(1.4), (2.2.), (4.1.), (8.1)	Physical therapist	Clinic	Yes	Yes	In clinic yes, at home no	Physical therapist	In clinic and at home	10 sessions over 8 weeks	30 minutes
<b>Coppack (2012) *</b> <i>Goal setting therapy</i>	(1.1), (1.3), (1.5), (1.6), (1.7), (4.1), (6.1), (8.1)	(2.1), (4.1), (6.1), (8.1)	Exercise specialist	Clinic	Yes	Yes	Yes, individual and group based	Exercise specialist	Clinic	Everyday	30 minutes
<b>Peterson (2015)</b> <i>Neck specific exercise and behaviour enhancement therapy</i>	(1.1.), (1.4), (4.1), (5.4) (6.1), (8.1), (8.6), (8.7), (12.6)	(4.1), (5.1), (6.1), (8.1), (8.6), (8.7)	Physio	Clinic	Yes	No	In clinic yes, at home no	Physio	In clinic and at home	2x per week	Not clear

<p><b>Friedrich (1998,2005)</b> <i>Motivation enhancement and exercise programme</i></p>	<p>(1.2), (1.4), (1.8), (2.3), (4.1), (5.1), (7.1), (8.7), (10.3), (10.4) (10.11)</p>	<p>(4.1), (6.1) (8.1), (8.6), (8.7)</p>	<p>Physio</p>	<p>Clinic</p>	<p>Yes</p>	<p>No</p>	<p>In clinic yes, at home no</p>	<p>Physio</p>	<p>In clinic and at home</p>	<p>10 sessions (2- 3x per week)</p>	<p>Exercise 25 minutes, motivation duration unclear</p>
<p><b>Harkapaa (1990, 1991) *</b> <i>Back school with relaxation, and counselling</i></p>	<p>(2.2), (3.1), (4.1), (6.1), (8.1), (12.6)</p>	<p>(2.2), (4.1)</p>	<p>Psychologist and physician</p>	<p>Local health club</p>	<p>Yes</p>	<p>Not clear</p>	<p>In clinic yes, at home no</p>	<p>Physio</p>	<p>In clinic and community health club</p>	<p>15 sessions (2x per week)</p>	<p>2 hours</p>
<p><b>Reilly (1989) *</b> <i>Personalised and monitored exercise programme</i></p>	<p>(2.2), (4.1), (6.1), (8.1)</p>	<p>(4.1)</p>	<p>Exercise specialist</p>	<p>Local health club</p>	<p>Yes</p>	<p>Yes</p>	<p>Yes</p>	<p>Exercise specialist</p>	<p>Community health club</p>	<p>4x per week</p>	<p>Not clear</p>
<p><b>Linton (1996) *</b> <i>Exercise and intensive counselling</i></p>	<p>(1.1), (1.2), (1.4), (1.5), (1.9), (7.1) (8.7)</p>	<p>(1.4), (12.5)</p>	<p>Behavioural psychologist</p>	<p>Not reported</p>	<p>Yes</p>	<p>Not clear</p>	<p>No</p>	<p>Behavioural psychologist</p>	<p>Community health club</p>	<p>Decided by participant (recommended 2x/week)</p>	<p>Exercise &gt; 20 min Counselling 2.5 hours</p>

*(1.1) Goal setting (behaviour), (1.2) Problem solving, (1.3) Goal setting (outcome), (1.4) Action planning, (1.5) Review behaviour goals, (1.6) Discrepancy between current behaviour and goal, (1.7) Review outcome goal(s), (1.8) Behavioural contract, (1.9) Commitment, (2.1) Monitoring of behaviour without feedback, (2.2) Feedback on behaviour, (2.3) Self-monitoring of behaviour, (2.6) Biofeedback, (3.1) Social support (unspecified), (4.1) Instruction on how to perform a behaviour, (5.1) Information about health consequences, (5.4) Monitoring of emotional consequences, (6.1) Demonstration of behaviour, (7.1) Prompts/cues, (8.1) Behavioural practice/ rehearsal, (8.6) Generalisation of a target behaviour, (8.7) Graded tasks, (9.1) Credible source, (9.3) Comparative imagining of future outcomes, (10.3) Non-specific rewards, (10.4) Social reward, (10.11) Future punishment, (12.5) Adding objects to the environment, (12.6) Body changes, (13.2) Framing/reframing*

Note: Bolded codes signify BCTs used in both treatment and control conditions

\*Trials observing significant in-between differences in control and treatment groups