

INTRODUCTION

Musculoskeletal conditions are the highest contributors to years lived with disability worldwide (Cieza et al., 2019). In the United Kingdom (UK) musculoskeletal conditions account for 20% of General Practitioner consultations (Jordan, 2010). There is clear evidence that self-management, in particular home exercises provided by physiotherapists, can effectively reduce the pain and disability associated with musculoskeletal conditions (Babatunde et al., 2017). However, systematic reviews report that up to 44% of patients do not engage with self-management strategies (Söderlund et al., 2021) and up to 67% fail to adhere to prescribed home exercises (Peek et al., 2016). Patients therefore risk ongoing pain, decreased function, increased work disability and financial instability, poorer quality of life and more frequent yet ineffective use of health services (Versus Arthritis, 2021).

Determinants are factors which are associated with adherence and could plausibly influence it. Often termed barriers and facilitators, they include psychological, social, and environmental influences as well as the therapeutic relationship. Many determinants can be modified and can be targeted using Behaviour Change Techniques (BCTs) (Michie et al., 2013), the active ingredients of an intervention that promotes behaviour change. Examples of BCTs include goal setting and feedback. The Behaviour Change Taxonomy (BCCTv1) provides a comprehensive list and accompanying definitions of 93 BCTs (Michie et al., 2013). However, identifying the determinants of importance for increasing exercise adherence or self-management, for any one patient, then selecting the appropriate BCTs to target those determinants, and integrating them into treatment is a new area of practice for physiotherapists. Currently physiotherapists use only a small number of the BCTs available (Kunstler et al., 2018; Söderlund et al., 2021).

The MRC framework recommends that prior to developing a complex intervention such as behaviour change, it is important to develop a theoretical understanding of the process, based on existing theory and evidence (Craig et al., 2013). There is no evidence base to guide physiotherapists to select BCTs specific to self-management and home exercise adherence. Based on international consensus, two related models for categorising

determinants (barriers and facilitators) have been developed irrespective of the desired behaviour.

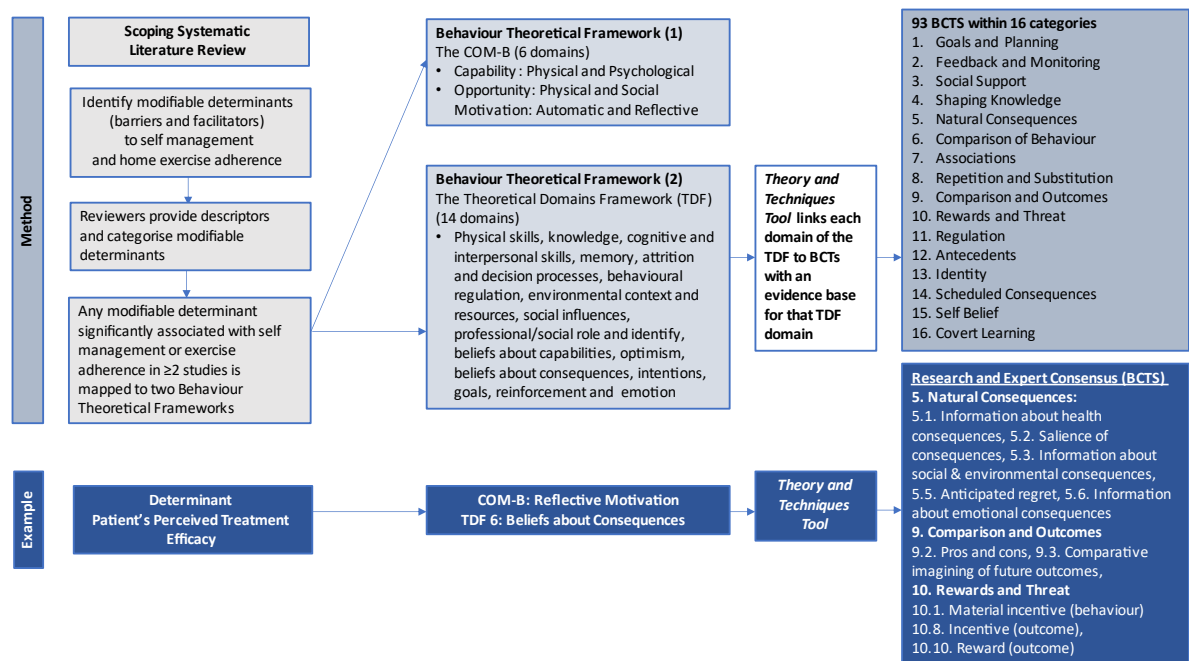
One of these models is the Capability, Opportunity, Motivation – Behaviour (COM-B), which states that three components contribute to any behaviour: Capability, Opportunity, Motivation (Michie et al., 2014). Capability may be physical or psychological, opportunity may be physical or social, and motivation maybe reflective or automatic motivation. This basic model allows easy integration into clinical practice.

The Theoretical Domains Framework (TDF) (Cane et al., 2012) is a slightly more complex model with 14 categories. For example, whereas the COM-B has just one category for psychological capability, the TDF has four: knowledge; cognitive and interpersonal skills; memory attention and attrition processes; and behavioural regulation. Based on i) an expert consensus study (Connell et al., 2021) and ii) literature synthesis (Carey et al., 2021), the TDF has been mapped to the evidence base for each BCT (Connell et al., 2021; Carey et al., 2021; Johnston et al., 2021). Therefore, any identified determinant (barrier or facilitator) for a behaviour (e.g., exercise adherence) that is mapped to the TDF, can in turn be mapped to recommended BCTs.

The objectives of our scoping review, are to:

1. To identify the modifiable determinants (barriers and facilitators) of adherence to exercises and self-management advice for the physiotherapy management of people with musculoskeletal problems (See figure 1).
2. To map the determinants identified from objective 1 to the domains and constructs of the TDF (and so consequently COM-B), and then to BCTs (See figure 1).
3. For determinants with supporting evidence from two or more studies, provide examples of how BCTs can be operationalised to increase adherence when delivering an exercise programme or self-management strategy.

Figure 1 Logic Diagram demonstrating Mapping Process



MATERIALS AND METHODS

This scoping review was conducted and reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco 2018). The study was not registered in PROSPERO.

Literature search

Medline, Embase, CINAHL, and AMED were searched via Ovid from inception (Medline 1946, EMBASE 1974, CINAHL 1981, EMCARE 1995) to December 2021 using MESH terms, text terms and Boolean operators. The search was updated in January 2023 for publications up to and including December 2022. The amalgamated full search strategy is presented in supplementary file 1.

Study selection

Full text quantitative, and mixed method studies published in the English language, which investigated potential determinants to patient adherence to exercises or advice on self-management provided by physiotherapists were eligible. Retrospective case series and

conference proceedings were not eligible. This was specific to people aged 18 and above attending physiotherapy for the management of musculoskeletal problems. Studies were excluded if they investigated in-patient populations, participants with additional life-threatening conditions, systemic musculoskeletal conditions being managed primarily by drug therapy, falls clinics or prevention. Two reviewers independently screened the study titles, abstracts, and full-texts for eligibility (RC, HD, PB, PK, or AB) carried out data extraction (RC, HD, PB, CW, PK) and quality assessment (RC, HD, FN, PK or SMC). Disagreements were resolved through discussion and referred to the Behavioural Psychologist on the team for further discussion if necessary.

Data extraction

Although adherence is distinct from compliance and engagement, these terms are sometimes used interchangeably in the literature. “Adherence” is a generic term covering multitude domains, for example, frequency, duration, and intensity of the agreed behaviour or exercise and whether performed as agreed (Frost et al., 2017; Bailey et al., 2018). There was wide variability between studies in the extent to which these were described. Where available, the definition or measure of adherence, and rate of adherence have been reported. Only modifiable determinants, that is determinants that can be changed, were included in this review and mapping exercise. Two independent reviewers (RC, HD or PB) extracted full details of each potential determinant and whether there was a statistically significant association with self-management and adherence. Study characteristics recorded included lead author, year and country of publication, study design, and number of participants.

Quality assessment

Two independent reviewers assessed Risk of bias (RoB) using the Quality in Prognosis Studies (QUIPS) tool for cohort studies (Hayden et al., 2013) and the Appraisal tool for Cross-Sectional Studies tool (AXIS) for cross sectional studies (Downes, 2016). The QUIPS tool measures risk of bias as low, moderate, or high on six domains: study participation, attrition, prognostic factor measurement, outcome measure, confounding measurement and account, and statistical analysis. Authors followed the guidance provided by Hayden (2013) for rating each domain. The overall risk of bias was based on the highest risk of bias

in any of the six domains. For example, if five of the six domains were rated as low, and one as moderate, the overall score would be moderate. In the absence of clear guidelines for rating overall RoB using the AXIS, we categorised studies with an overall score of $\geq 16/20$ as low RoB, 12-15/20 as moderate RoB and ≤ 11 as high RoB. Cohort studies were given greater weighting than cross sectional studies, given the former's longitudinal nature and their ability to identify prognostic factors for adherence. Recommendations were based on guidance from Guyatt et al (2021).

Mapping

Three independent reviewers (RC, HD, PB) mapped each determinant to the TDF and consequently to the COM-B model, using existing mapping work (Cane et al; 2012). For example, "Clarifying understanding of exercise programme" and "Summarising management strategies back to physiotherapist" from three of the studies (Medina-Mirapex et al., 2009; Chan et al., 2010; Peek et al., 2020) was mapped to "Knowledge" within the TDF, which maps to "Psychological Capability" within the COM-B model. Some studies presented composite scores for questionnaires, whose items covered a variety of determinants from several domains. The results could therefore not be mapped to any one domain or construct of the TDF or COM-B. Where individual determinants could be mapped to more than one TDF domain, we selected the best fit through discussion with the teams Behavioural Psychologist.

Determinants, which demonstrated significant associations with adherence and were supported by two or more studies were mapped to potential BCTs using the online Theory and Techniques Tool (TTT) (Johnston et al., 2021) (figure 3). The TTT maps the domains of the TDF, called Mechanisms of Action (MoA) and 12 additional MoA to potential BCTs. Each cell within the TTT provides an indication of the strength of the link between the TDF and BCTs based on an expert consensus study and literature synthesis. The strength of evidence for each BCT is explicitly stated in figure 3, that is when the mapping was supported by both expert consensus and literature synthesis or just one of these. When the TTT did not report a link between a TDF domain and a specific BCT, this was due to either a lack of evidence or evidence of no association. When there was a lack of evidence, based on the teams' clinical experiences, we therefore selected and documented additional BCTs that we felt may be

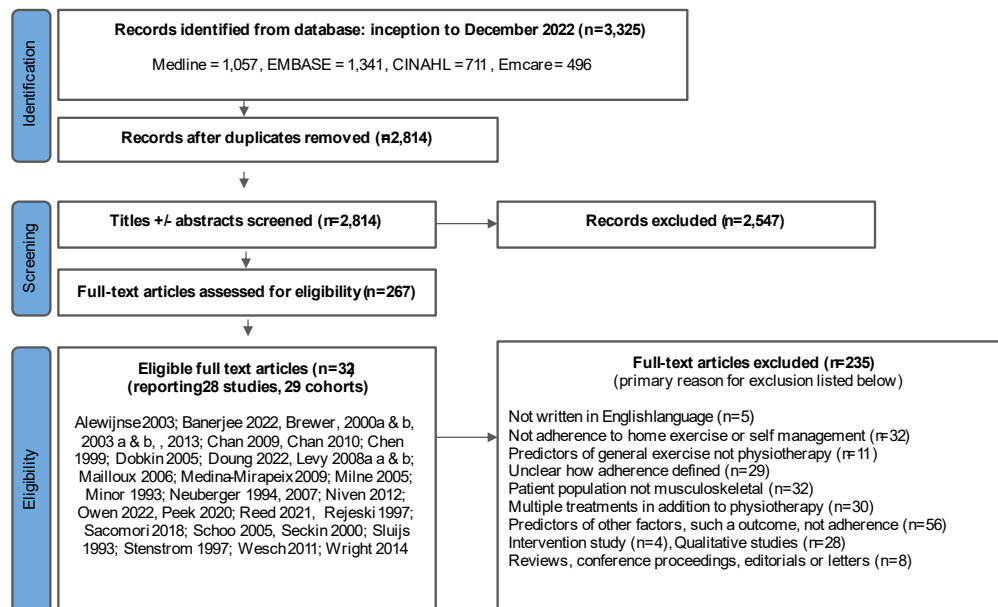
relevant within the physiotherapy clinical context. For the BCTs mapped to each unique TDF and COM-B combination, we have provided an extensive list of example interventions mapped to the functions and policies of the Behaviour Change Wheel (Michie et al., 2014).

RESULTS

Study characteristics

The results of the search strategy are presented in the PRISMA flow diagram in figure 2. A total of 32 publications, describing 29 cohorts were included in the final review: four publications referred to one cohort (Brewer et al., 2000a, 2000b, 2003a, 2003b), two publications referred to another cohort (Levy et al., 2008a, 2008b) and one publication referred to two studies (Milne et al., 2005). This provides 28 summaries in table 1.

Figure 2: PRISMA Flow Diagram



Study characteristics, including summary scores for quality assessment are presented in table 1. Ten studies scored high on the QUIPs RoB, ten moderate and eight low. Three studies scored $\geq 16/20$ on the AXIS, with the remaining two studies scoring 15/20 and 11/20. Results for each component of the quality assessment are provided in supplementary file 2.

Studies took place in the following countries: USA (n=8), Australia (n=5), Canada (n=3), Netherlands (n=2), Turkey (n=2), UK (n=3), Brazil (n=1), Hong Kong (n=1), Spain (n=1), Sweden (n=1). Study designs included 16 prospective (described in 19 papers) and one retrospective cohort, six cross-sectional studies (described in five papers), and four randomised controlled trials.

The total number of participants at baseline was 5279. There was significant variability in how adherence was investigated, its definition, measurement, and follow-up period. Some home exercise adherence measures were reported by clinicians, others by patients, sometimes a mixture of both. Adherence referred to frequency, duration, intensity, effort, correctness, quality, or proportion completed. The most common measure was a Numerical Rating Scale ranging from 3 to 10 points. Further details of adherence measures are provided in supplementary file 3. Overall adherence rates ranged from 28% (Mailloux et al., 2006) to 90% (Welsch et al., 2012). Adherence rates were not always stated (Chan et al., 2009, Levy et al., 2008b, Banerjee., 2022) or clearly defined (Brewer et al., 2000b,2003a; Levy et al., 2008a) despite being included in later inferential analyses.

Table 1: Study characteristics and quality assessment summary

Study (1st Author, Date, Country, Study Design)	Participant number at start/final analysis	Population	Adherence rates	QUIPS score
Alewijnse (2003), Netherlands Prospective cohort	133/103	Women. Risk factors urinary incontinence	67% of participants stated they still followed the behavioural advice 4-7 days per week at 1 year follow-up	Low
Banerjee (2022)	270/153	Chronic LBP	Self-management was measured using a 40-item Health Education Impact Questionnaire (heiQ) (Osborne et al., 2007), Adherence rate not reported	Mod
Brewer (2000a, 2000b, 2003a, 2003b), USA Prospective cohort	(2000) a) 80/80 b) 95/95 (2003) a) 85/85 b) 61/61	Post-Op ACL reconstruction	Self-report completion of home exercises on Scale from 1 (none) to 10 (all): 2000a at 6 months mean 7.53 ± SD1.93, 2000b and 2003a unclear, 2003b mean 7.58 ± SD 1.95 time point unclear	Mod
Brewer (2013), USA Prospective cohort	91/86	Post-Op after ACL reconstruction	Mean ±SD number of exercise sets completed for 42 days postoperatively divided by number of exercise sets prescribed. 1.43 ± 1.44	High
Chan (2009), Hong Kong Retrospective cohort	115/115	Post-Op after ACL reconstruction	3 items rated on a 7-point Likert Scale where 1 is no and 7 maximum adherence (5.50+/- SD 1.16; range, 2.50 –7.00)	High
Chan (2010), Turkey Prospective cohort	82/82	Subacute MSK/ortho. conditions	39% achieved 100% adherence on 25 item questionnaire with 5-point Likert scale	High
Chen (1999), USA Prospective cohort	102/62	Upper-extremity impairment, Ortho	Number of exercises completed divided by number of exercises a) remembered by patient 74% b) prescribed by physiotherapist 35%	Mod
Dobkin (2005), Canada Prospective cohort	39/33	Females with fibromyalgia	At 3 months 85% were adhering to the study exercise protocol	Mod
Duong (2022) Australia Prospective cohort	51/42	Post-OP TKR	Number of steps divided by number prescribed, reported as percentage: 24% of patients >100% adherent, 16% adherent (80-90%), 20% low adherence (0-79%).	Mod

Levy (2008a, 2008b), UK Prospective cohort	70/70	Athletes with tendonitis (overuse)	Not reported	High
Mailloux (2006), USA Prospective cohort	192/89	Elderly with chronic low back pain	28% at 2 years follow up	High
Medina-Mirapeix (2009), Spain, Prospective cohort	250/184	Chronic non-specific neck or low back pain	Adherence to prescribed exercise i) duration per session (70.1%; CI = 63.0 to 77.2) ii) frequency per week (60.7%; CI = 53.7 to 67.7)	Low
Miline (2005), Canada 2 studies, Cross-sectional	1) 237/237 2) 270/270	Athletic injuries	Exercise quality (mean 80% \pm SD13), frequency (mean 89 \pm 27), and duration (91 \pm 25)	Low
Minor (1993), USA, RCT	120/83	OA and RA	Not reported	Mod
Neuberger (1994), USA Cross-sectional	100/100	OA and RA	Self-report for exercise in previous 7 days: 46% did not perform range of movement and 76% had not performed strengthening exercises	High
Neuberger (2007), USA, RCT	310/220	RA	Not reported	Low
Niven (2012), UK Prospective cohort	87/48	Post Op ACL reconstruction	Mean \pm SD self-reported adherence, 7-point Likert Scale (1:no adherence). At wk 2: 5.60 \pm 0.85, wk 4: 5.39 \pm 0.1.26, wk 6: 5.63 \pm 0.99, w 8: 5.32 \pm 1.43	High
Owen (2022) Australia RCT	40/32	Chronic LBP	Average attendance was 77% (motor control and manual therapy) and 60% (General Strength and Conditioning) with eight dropouts.	Mod
Peek (2020), Australia Cross-sectional	113/113	Acute/chronic MSK or Neuro condition	56% of 232 prescribed self-management strategies had >50% adherence	High
Reed (2021) UK Prospective cohort	141/141	Females with any Incontinence	Home exercise adherence not measured. 68 completed course of physiotherapy (attended all sessions).	Mod
Rejeski (1997), USA, RCT	439/~220	Elderly, OA Knee	Unclear	Mod
Sacomori (2018), Brazil, RCT	86/72	Females with urinary incontinence	Self-report exercise performance at 3 month follow up: 60% every day, 21% 3-6 times per week, 10% 2-3 times a week, 4% not at all	Low

Schoo (2005), Australia Prospective cohort	115/90	OA Hip or Knee	Percentage of performed exercises from those prescribed: 52% \geq 90% adherent, 48% \leq 89% adherent	Low
Seckin (2000), Turkey Prospective cohort	120/120	OA Knee	Percentage of exercise sessions completed from those prescribed. First week: 90 \pm 2.3%, First month: 86 \pm 2.7%, Second month: 87 \pm 1.9%, Third month: 85 \pm 3.1%	High
Sluijs (1993), Netherlands Cross-sectional	1837/ 691	MSK conditions (90%)	61% adherent (exercised "very regularly" on 4-point Likert)	Mod
Strenstrom (1997), Sweden Prospective cohort	54/54	Inflammatory rheumatic diseases	65% completed 12-month exercise program	High
Wesch (2012), Canada Prospective cohort	90/90	Injury rehabilitation	Mean percentage score \pm SD from 2 questions for adherence frequency, 87 \pm 17.45), duration 99 \pm 25.18, quality 83 \pm 13.58	High
Wright (2014), Australia Cross-sectional	100/87	Musculoskeletal injuries	89% of participants reported completing all prescribed exercises, 73% reported completing at least 80% of their exercise	Low

Legend: Mod, Moderate; LBP, Low Back Pain; OA, Osteoarthritis; RA, Rheumatoid Arthritis; Op, Operative, TKR, Total Knee Replacement

Determinants and domains

Thirteen determinants were grouped under eight categories by the reviewers, with citations for supporting evidence (Figure 3): Explanation and Understanding, Physical Skills, Self-Efficacy, Perceived Treatment Efficacy, Number of Exercises, Therapeutic Relationship, Social Support and Task Appreciation, and Time and Prioritisation. Categories were defined based on the best headline summary for the determinant(s) they contained and the TDF to which they were mapped. Five categories included determinants that were enacted by the patient and/or physiotherapist in the cited evidence, the distinction not always clear in the texts. As well as patient characteristics, some of our determinants were BCTs in themselves.

The identified determinants mapped to seven of the 14 TDF domains: Knowledge, Skills, Beliefs about Capabilities, Beliefs about Consequences, Memory, Attention and Decision Processes, Environmental Context and Resources, Social Influences. Determinants were mapped to four of six possible COM-B components, the most frequent being psychological capability and reflective motivation. Several determinants could be mapped to more than one component of the COM-B model. Therefore, as a team, we selected the most fitting given the context. There was one determinant, Time and Prioritisation, for which this was not possible as it arose in a variety of contexts. This determinant was therefore mapped to two COM-B and three TDF domains (see figure 3).

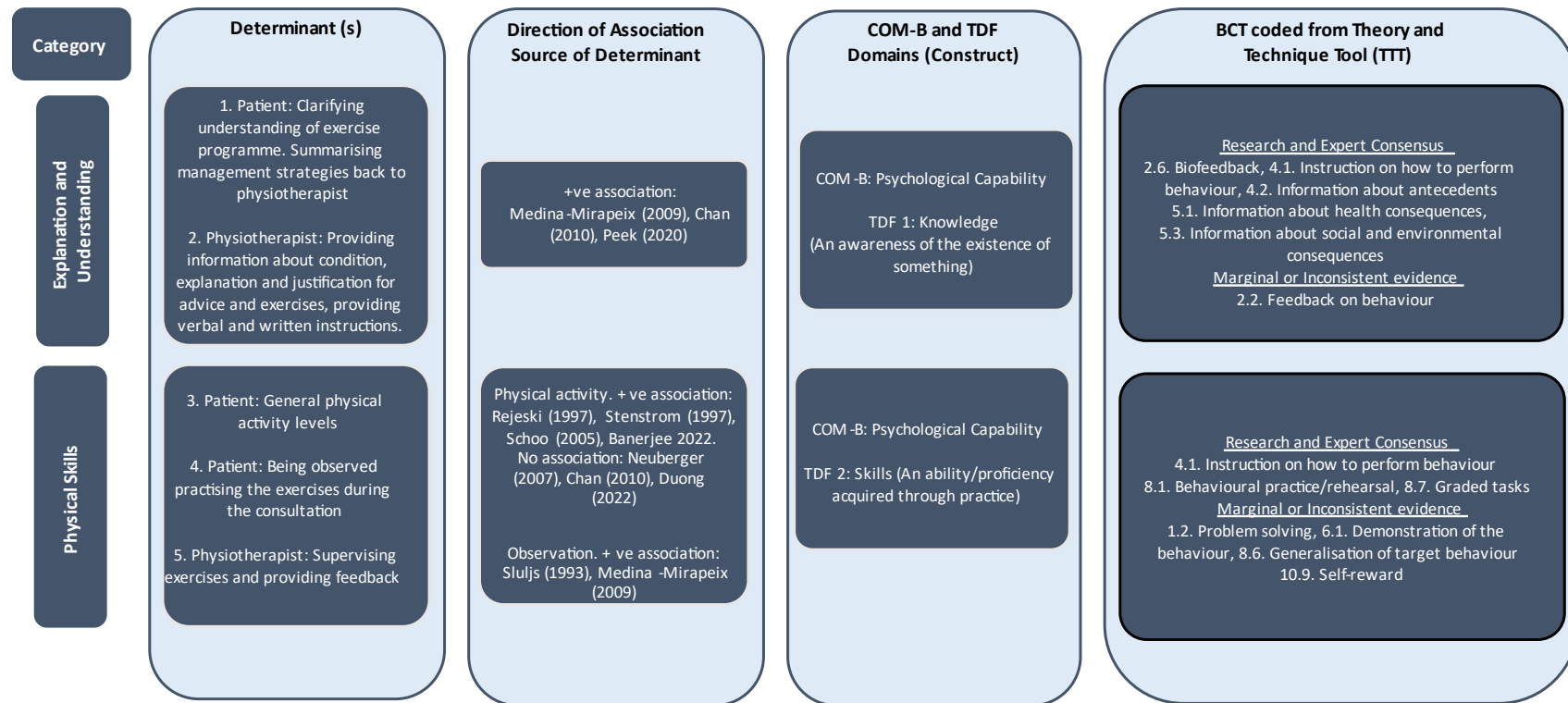
Applying the GRADE criteria (Guyatt 2011) to rate the certainty of evidence supporting the determinants we identified was challenging. We used guidance for rating the evidence in the absence of a single estimate of effect (Murad et al, 2017) and provide our reasoning for transparency. Only eight of the 28 cohort studies were of low risk of bias. A significant source of heterogeneity between studies was how adherence was defined, measured and the period of follow up. Clear definitions of determinants were not always provided. However, our population (n=5279) was largely representative of clinical practice. Statistical evaluation of publication bias was not possible. However, we did not suspect publication bias because our search for publications was extensive, and the smaller studies were no more likely to report a significant association than the larger or high-quality studies.

The only determinant that was supported by evidence from two or more cohort studies, specifically with low RoB, was exercise self-efficacy. A positive association between exercise self-efficacy and adherence was consistent in five of the six studies in which it was investigated. The only study investigating exercise self-efficacy that reported no association with adherence had a high RoB. Given the consistency of findings, and based on a variety of adherence measures, we are highly confident in these findings.

Some determinants had been investigated in only two or three studies. These were patient understanding, and physiotherapists providing information, being observed, receiving feedback, and number of exercises. However, the evidence for these determinants was consistent in demonstrating an association and included at least one cohort study with low RoB. We therefore have moderate confidence in these findings.

Evidence of a positive association between coping and task self-efficacy with adherence was the least consistent. Two cohort studies of moderate RoB and one cross sectional study of low RoB provided evidence of a positive association. However, five cohort studies, ranging from low to high RoB reported no association. We are therefore very uncertain if there is a true association. For the following determinants there was also evidence from some studies of no association with adherence: physical activity, perceived treatment efficacy, social support and task appreciation. However, these studies were of higher RoB and less or at the most equal in number compared to those showing an association. We therefore have low to moderate confidence in these findings.

Figure 3: Modifiable Patient Determinants Mapped to the COM-B, Theoretical Domains Framework (TDF) and Behaviour Change Technique Taxonomy (BCTTv1)



Category	Determinant (s)	Direction of Association Source of Determinant	COM-B and TDF Domains (Construct)	BCT coded from Theory and Technique Tool (TTT)
Self Efficacy	6. Patient: Exercise self-efficacy 7. Patient: Coping and task self - efficacy	Exercise self efficacy. +ve association: Stenstrom (1997), Milne (2005), Medina -Mirapeix (2009), Wesch (2011), Sacomori (2018). No association: Levy et al (2008b) Coping and task self efficacy. + ve association: Chen (1999), Brewer (2000a and b, 2003a and b), Wright (2014). No association: Alewijnse (2003), Dobkin (2005), Neuberger (2007), Niven (2012), Dong (for step counter) (2022), Owen 2022	COM -B: Reflective Motivation TDF 4: Beliefs about Capabilities (Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use)	<u>Research and Expert Consensus</u> 1.2. Problem solving, 4.1. Instruction on how to perform behaviour, 6.1. Demonstration of the behaviour, 8.1. Behavioural practice/rehearsal 8.7. Graded tasks, 15.1. Verbal persuasion about capability, 15.3. Focus on past success, 15.4. Self -talk <u>Marginal or Inconsistent evidence</u> 1.1. Goal setting (behaviour), 2.6. Biofeedback, 10.4. Social reward, 11.2. Reduce negative emotions <u>Our additional suggestions</u> 1.4 Action planning, 2.3 Self -monitoring of Behaviour, 3.1 social support (unspecified), 13.4 Valued self - identity
Perceived Treatment Efficacy	8. Patient: Perceived Treatment Efficacy	+ve association: Neuberger (1994, 2007), Brewer (2003). No association: Levy (2008b), Chan (2010), (Owen 2022)	COM -B: Reflective Motivation TDF 6: Beliefs about Consequences (Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation)	<u>Research and Expert Consensus</u> 5.1. Information about health consequences 5.2. Salience of consequences, 5.3. Information about social & environmental consequences, 5.5. Anticipated regret, 5.6. Information about emotional consequences 9.2. Pros and cons, 9.3. Comparative imagining of future outcomes, 10.1. Material incentive (behaviour) 10.8. Incentive (outcome), 10.10. Reward (outcome)
Number of Exercises	9. Number of Exercises	-ve association: Medina -Mirapeix (2009), Brewer (2013)	COM -B: Psychological Capability TDF 10: Memory, attention, and decision processes	<u>Research and Expert Consensus</u> 7.1. Prompts/cues, 11.3. Conserving mental resources <u>Marginal or Inconsistent evidence</u> 1.9. Commitment, 7.8. Associative learning, 8.4. Habit reversal

Category	Determinant (s)	Direction of Association Source of Determinant	COM-B and TDF Domains (Construct)	BCT coded from Theory and Technique Tool (TTT)
Therapeutic Relationship	10. Patient and Physiotherapist: Establishing effective communication, active listening, interested and concerned in comprehensive list of problems, clarifying doubts, answering questions	+ve association: Sluijs (1993), Levy (2008b), Medina-Mirapeix (2010), Wright (2014)	COM -B: Physical Opportunity TDF 11: Environmental Context and Resources (Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour).	<u>Research and Expert Consensus</u> 3.2 Social Support (practical), 7.1 Prompts/cues, 7.5 Remove aversive stimulus, 12.1 Restructuring the physical environment, 12.2. Restructuring the social environment, 12.3 Avoidance/reducing exposure to cues for the behaviour, 12.5. Adding objects to the environment <u>Marginal or Inconsistent evidence</u> 1.2 Problem solving, 11.3. Conserving mental resources
Social Support & Task Appreciation	11. Patient: Social support network, including emotional and practical support 12. Physiotherapist: Task appreciation	+ve association: Minor (1993), Oliver (2002), Medina - Mirapeix (2009);Levy (2008b), Chan (2009, 2010). No association: Rejeski (1997), Brewer (2003), Neuberger (2007), Wright (2014)	COM -B: Social Opportunity TDF 12: Social Influences (Interpersonal processes that can cause individuals to change their thoughts, feelings or behaviours)	<u>Research and Expert Consensus</u> 3.1. Social support (unspecified), 3.2. Social support (practical), 6.2. Social comparison, 6.3. Information about others' approval, 10.4. Social reward <u>Marginal or Inconsistent evidence</u> 2.1. Monitoring of behaviour by others without feedback, 12.2. Restructuring the social environment <u>Our Additional Suggestions</u> 2.2 Feedback of behaviour, 2.3 Self-monitoring of Behaviour
Time and Prioritisation	13. Patient: Perceived Time. Exercises take too much time, do not fit with daily routine, are a waste of time, boring. Forget to exercise.	-ve association: Sluijs (1993), Dobkin (2005), Medina Mirapex (2019)	COM -B: Physical Opportunity TDF 11: Environmental Context and Resources (See earlier rows for description of TDF) COM -B: Reflective Motivation TDF 4: Beliefs about Capabilities COM -B: Reflective Motivation TDF 6: Beliefs about Consequences	See earlier rows for mapping dependent upon COM-B and TDF domain

For the following determinants, all the studies in which they were investigated reported a positive association, that is they are facilitators of adherence: encouraging patients to clarify their understanding of the agreed management plan and providing the patient with an explanation and justification for their exercises (TDF Knowledge), supervising the patient do their exercises during the consultation (TDF Skills); providing less rather than more exercises (TDF Memory, Attention and Decision Processes), ensuring a good therapeutic relationship (TDF Environmental Context and Resources), and patients perceiving they have the time, and will remember, to do their exercises (TDF Environmental Context and Resources, Beliefs about Capabilities and Consequences). Likewise, the following determinants were negatively associated with adherence, that is they are barriers to adherence: providing more rather than less exercises (TDF Memory, Attention and Decision Processes), patients perceiving they do not have the time, and or will remember, to do their exercises (TDF Environmental Context and Resources, Beliefs about Capabilities and Consequences).

Behaviour Change Techniques

The determinants were mapped to 42 of the 93 BCTs available using the TTT. This represents 13 out of the 16 BCT clusters in version 1 of the taxonomy. In addition, for exercise, coping and task self-efficacy we selected one additional BCT (*Action Planning*), for which the TTT did not provide an evidence-based link. The six groups of BCTs that featured most frequently were: *Goals and Planning, Feedback and Monitoring, Natural Consequences, Repetition and Substitution, Reward and Threat, and Antecedents*. The single most common BCT to which any of our determinants were matched was *Problem Solving*, which was mapped five times. One BCT, *Instruction on How to Perform Behaviour* was mapped four times and 12 BCTs three times. Examples of clinical application of these BCTs during a physiotherapy consultation are presented in figure 4 and table 2.

Figure 4: Examples of Interventions to Facilitate Adherence to Physiotherapy Home Exercises



Table 2: Examples of Interventions to Facilitate Adherence to Physiotherapy Home Exercises

Exercises

Bob is a 65-year-old retired plumber who is attending physiotherapy for the management of degenerative knee pain. His main difficulty is climbing the stairs to his flat and most important to him is returning to basic DIY tasks for friends.

Time point	Intervention	BCT	Determinant
A: Pre-consultation	1. Bob’s appointment letter asks him to have already thought about what will help or hinder him carrying out his physiotherapy at home and be ready to discuss this.	Problem solving	Therapeutic relationship
B: Instruction of Exercise Prescription	1. Physiotherapist asks Bob what is important to him (DIY) and makes explicit links between Bob’s return to DIY and the exercises selected for him.	Valued self-Identity	Self-efficacy
		Information about environmental and social consequences	Perceived treatment efficacy
	2. Physiotherapist encourages Bob to palpate his thigh muscles during his exercises to feel them working.	Biofeedback	Understanding
	3. Bob records himself doing the exercises on his phone while the physiotherapist provides instructions and feedback.	Instruction and feedback on performing behaviour	Understanding and Physical Skills
	4. Bob is provided with a max. of 3 exercises including illustrations and basic instructions on one side of A4	Conserving Mental Resources	Number of Exercises
	5. Bob masters step ups before tackling flights of stairs	Graded Tasks	Exercise and Task Self-efficacy
	6. In later stages of rehab Bob is asked to practise the functional task of getting on/off the floor, simulating DIY activities	Behavioural Practice/ rehearsal	Physical Skills
C: Strategies to overcome barriers	1. Bob is asked how he will justify his exercises and self-management programme to his wife who feels he needs surgery rather than physiotherapy	Information about Health Consequences	Explanation and Understanding, Perceived treatment efficacy
	2. Bob’s identifies his granddaughter as someone who will text him, reminding him to exercise	Social Support (Practical)	Time and Prioritisation
	3. Physiotherapist and Bob develop strategies to overcome flareups, periods of low confidence in performing exercises and managing the fatigue associated with increased physical activity levels. (These might include videos of lower-level exercises and mindfulness techniques).	Problem solving	Self-efficacy
	4. Bob signs up to a digital health / exercise platform that reminds him when to do his exercises. He can also record when he completes his exercises each day. The app then sends an automated encouraging response.	Self-monitoring of behaviour, Prompts and Cues, Social Support (Unspecified).	Time prioritisation, Social Support and Task Appreciation
	5. The digital health / exercise platform provides a voucher as a reward for “steps/flights climbed”	Material Incentive (Behaviour)	Treatment efficacy
	6. Physiotherapist refers Bob to the knee class to exercise alongside others with similar conditions	Demonstration of Behaviour and Social Support (Unspecified)	Exercise, coping and task Self-efficacy
			Social support

	7. Bob's knee class have a "WhatsApp" group and they congratulate one another on milestones and task performance	Social reward and Social Support (unspecified)	
D: Follow up	1. Bob's digital app data is discussed with physiotherapist	Feedback on Behaviour	Task Appreciation
	2. Bob uses a smartwatch to record his step count to record how his activity levels are increasing	Self monitoring of behaviour	Task self-efficacy
E: On discharge	1. Physiotherapist provides GP with a patient progress report which includes comments on exercise adherence and engagement with self-management	Feedback on behaviour	Task appreciation/ social support
	2. Bob is signposted to a local walking group	Social Support (Practical)	Social Support/ Task Appreciation

Supplementary file 4 provides further details of how each determinant was mapped to BCTs, and Behaviour Change Wheel functions and policies and provides examples of interventions specific to each BCT that could be delivered by physiotherapists. The most frequently occurring functions are those that the practitioner can autonomously decide whether to use, and perhaps represent those commonly used in practice, for example, education, training, and persuasion. Policies are less frequently mapped and include guidelines and service provision, environmental/social planning, regulation, and communication /marketing.

DISCUSSION

Our systematic literature review identified evidence for 13 modifiable barriers and facilitators (influencing factors) relevant to physiotherapy practice for musculoskeletal problems. Some of the factors relate to patient characteristics or actions carried out by patients, whilst others relate to the actions of the physiotherapist. We mapped the TDF and COM-B to BCTs. We then provided clinical practice examples of how BCTs might be used to increase adherence to home exercise programmes or engagement with self-management.

Given the extensive number of BCTs available, we have provided physiotherapists with high-quality synthesised evidence to understand which BCTs might be relevant to their clinical practice and the patient in front of them and provided support for the effective uptake and application of this knowledge into practice.

The 13 determinants identified in this review, mapped to four of the six COM-B categories: psychological capability, reflective motivation, social and physical opportunity, with notably more mapped to the former two categories. None of our determinants mapped to physical capability or automatic motivation.

Physical capability is the key target of physiotherapy interventions which are designed and tailored to be within the patient's current physical capability. Patients are therefore not provided with exercises for which they do not have the physical skills to perform as this would be unsafe practice. We therefore mapped physical skills to psychological capability on the COM-B. For example, higher general physical activity levels reflect a psychological familiarity with movement and exercise.

Automatic Motivation includes emotional, impulsive reactions and desires (Michie et al., 2014). Only two determinants mapped to automatic motivation. Depression was not associated with outcome in one study (Rejeski et al., 1997) and was negatively associated with outcome in two studies (Minor et al., 1993; Banerjee., 2022). Neuroticism was not associated with outcome in two studies (Brewer et al., 2013, Castenda et al., 1998) and negatively associated in one (Wright et al., 2014). We did not include these within our mapping as we felt that these would not be modifiable within a physiotherapy setting.

The three most frequently used BCTs by physiotherapists for shoulder pain (Hall et al., 2021), are also amongst those with the greatest evidence for their effectiveness (Meade et al., 2019): Goal setting, Instruction and Demonstration of behaviour, and Behaviour practice/rehearsal. However, these BCTs mapped to only four of our determinants. For the remaining nine determinants, alternative BCTs may be more appropriate based on the TTT, which includes evidence from outside the field of physiotherapy.

Research shows that physiotherapists on average use six BCTs (Hall et al., 2021), but our review has identified that there are 42 BCTs, with an evidence base, that could be used to target modifiable determinants of exercise adherence. A clear challenge is to find ways to cascade learning and upskilling of physiotherapists about how to use this information to

select BCTs that are relevant to their clinical practice. Integrating behaviour change science into existing pre- and post-graduate curriculum will help to promote a culture of its integration into standard clinical practice. In addition to contributing to enhanced communication it is also an evidence-based intervention.

Implications for future research

The BCTs selected in this review were based on the TTT, an evidence base for any health-related behaviour change, for example, smoking cessation or hand washing. We recommend that the effectiveness of these BCTs is explored specifically for patients attending physiotherapy with musculoskeletal problems.

The determinants in our review mapped most frequently to “problem solving.” Whilst the TTT supports the mapping, there is currently a lack of research exploring the evidence base for its effectiveness in our population (Thacker et al., 2021) and it is rarely used by physiotherapists in practice with respect to exercise adherence (Hall et al., 2021). Based on the dominance this BCT played in our mapping exercise, we recommend that future research should investigate why physiotherapists do not choose to use problem solving, its effectiveness when they do and how its integration can be facilitated.

Future randomised controlled trials that investigate the effectiveness of BCTs, should ensure there is a clear distinction from the control group. The component of adherence being addressed, for example, whether initiation or maintenance, frequency, duration or quality of exercise or self-management should be stated. Within the control group physiotherapists may intuitively integrate BCTs into their treatments and this needs to be monitored. Assessment of treatment fidelity and process evaluation is important in both groups.

The effectiveness of tailoring BCTs to the determinants of importance for individual patients needs to be investigated. This should include which combinations may be complementary to one another, and the extent to which using more BCTs can result in redundancy or counterproductivity.

Implications for clinical practice

The strongest and most consistent supporting evidence in our review was for the association of exercise self-efficacy with adherence. We therefore recommend that physiotherapists routinely assess this in their clinical practice. The measures or terminology used to assess exercise self-efficacy should be clearly distinguishable from coping and task self-efficacy, for which evidence of an association with adherence was inconsistent.

Our review and mapping show that factors that influence the extent to which patients adhere to exercise and engage with self-management belong to both the patient and physiotherapist. Evidence from a previous study suggests that physiotherapists tend to target patient's knowledge and skills as a key determinant (Hall et al, 2021), using BCTs associated with providing information and instruction about how to perform the exercises. However, our review indicates that there is a far broader range of determinants for which providing information and instruction may not be appropriate. For example, the TTT does not map these BCTs to the following determinants: number of exercises, perceived time to do the exercises and task appreciation. The TTT highlights that a defined selection of BCTs are effective at targeting each determinant. Selecting the most appropriate BCTs to target the determinants of importance for any one patient, is therefore important. Our mapping provides a guide for physiotherapists to do this.

Based on the frequency with which these BCTs were mapped to our determinants, we recommend physiotherapists consider utilising: problem solving, information about health consequences and social support. Previous research has shown that these are not commonly used by physiotherapists in practice (Hall et al., 2021).

Problem solving was the most frequent BCT identified in our mapping exercise. Problem solving involves prompting the patient to analyse factors influencing their likely exercise adherence and engagement in self-management, and importantly generate and/or select their own strategies to overcome any barriers (Michie et al., 2014 p259). Ideally problem solving should be shared, empower the patient, and include strategies for relapse prevention, exercise, and self-management task self-efficacy. Physiotherapist's already use problem solving to good effect when empowering patients to manage their musculoskeletal problems at work (Johnston and Shaw 2013). However, we have provided examples

relevant to physiotherapy practice which may enhance the effectiveness of problem solving as a BCT with respect to adherence and self management.

The TTT mapped social support to three of our determinants. It is arguably the BCT with the greatest evidence base within the field of physiotherapy (Meade et al., 2019; Thacker et al., 2021) yet it is less commonly used by physiotherapists on a one-to-one basis (Hall et al., 2021). We recommend that physiotherapists consciously consider how this BCT can be utilised. An example of social support is providing gym classes and low back pain education groups. Physiotherapists should not underestimate the role of peer supported self-help groups in providing encouragement or the role of family and friends and that social support also targets an individual's existing social support network, whether that be via online communities, from friends and family or through work.

Knowing what influences physiotherapists' selection of BCTs is important, for example, the skills and confidence required to deliver effective BCTs, and their practical application into a busy clinical consultation. A potential solution is to embed BCTs into the many emerging digital health technologies being developed within the musculoskeletal field, as this is likely to help facilitate the use of BCTs in mainstream practice. For example, patients are increasingly asked to complete pre-assessment online questionnaires, which could include assessments of potential individual barriers or facilitators to exercise adherence and self-management engagement. Digital algorithms could also be used to help suggest to clinicians and to patients, which BCTs might be best to target for an individual patient. In addition, better digital infrastructure provides an opportunity to better monitor, reward and provide positive feedback and social support for exercise adherence. The potential for improved behaviour change science to be integrated within the digital transformation of musculoskeletal care is an exciting future direction for research and clinical practice.

Strengths and limitations

The comprehensive theoretical frameworks upon which we have based this review, have enabled us to provide a theoretical underpinning of the components involved in exercise adherence and self management. Categorising and mapping these components, aids both understanding and replication. This forms a basis on which to report the evidence. In

addition, this review provides a practical framework and guidance for clinicians integrating BCTs into their practice.

Our review only included quantitative studies, with predefined factors for measurement, and this may account for the limited number of determinants identified as qualitative studies, using interviews for example, may have provided opportunities for participants to highlight further determinants. This limitation may also account for a lack of determinants in the COM-B category “automatic motivation” and “physical capability”, as these factors are more challenging to measure and perhaps therefore missing from quantitative studies. Defining, categorising, and mapping determinants to the COM-B and TDF was carried out by ourselves rather than individual study authors and therefore limited detail in some publications may have led to inaccurate mapping. Where ambiguity existed, this is stated in the text.

Determinants for initiating exercise adherence in contrast to maintaining exercise adherence and self-management engagement were rarely distinguished in the reviewed studies and were therefore not distinguished in our review. There are no reliable validated measures of adherence (Bailey et al., 2020) and there was considerable heterogeneity in the components measured. This has implications for the reliability of individual study results. The determinants of importance for different aspects of adherence may vary. In addition, the strength of evidence for determinants was based on the frequency of association rather than strength of association. Some potential determinants may not have been investigated. For example, there were some determinants that we expected to find significantly associated with adherence, such as kinesiophobia or fear avoidance. However, for these potential determinants, there was lack of evidence rather than evidence of no association. To be included in our mapping, determinants had to have been investigated extensively enough to report a statistically significant association in two or more studies. There were no deviations from our protocol. The possibility of language bias cannot be excluded as we only included manuscripts written in English.

The evidence base for BCTs is still developing. The Theory and Techniques Tool is a resource for linking Behaviour Change Techniques and Mechanisms of Action for any behaviour

change intervention, based on published scientific studies and expert consensus. When the team felt there was potential for additional links between the TDF and BCTs in the context of this review, this has been highlighted.

CONCLUSIONS

Our systematic literature review suggests that self-efficacy (including coping and task self-efficacy), social support and task appreciation are the most evidence-based determinants. Overall, the determinants identified mapped onto half of the TDF domains and in turn approximately half of BCTs in the taxonomy used. This indicates multiple ways of targeting these identified determinants, most of which are not routinely employed during physiotherapy.

By identifying determinants to home exercise adherence and self-management and mapping these to BCTs, this review has improved understanding of the selection, targeting, and potential application of relevant BCTs to musculoskeletal physiotherapy practice. This provides support for physiotherapists targeting the determinants of importance for the patient in front of them.

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