The characteristics, components, and fidelity of interventions promoting physical activity in people living with musculoskeletal conditions: a systematic review

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REVIEW

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The characteristics, components, and fidelity of interventions promoting physical activity in people living with musculoskeletal conditions: a systematic review

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ABSTRACT

Purpose: Musculoskeletal disorders (MSKDs) create a significant burden on individuals and healthcare systems. Physical activity (PA) is recommended to support people with MSKDs. Limited understanding exists of the components, characteristics, and fidelity of interventions aiming to support transition to increased PA. Determining what works to support transition to increased PA is therefore difficult. This systematic review aims to address this gap and summarise the common traits of interventions that helped improve PA in people with MSKDs.

Methods: Systematic search and review were undertaken to find effectiveness studies of PA interventions in MSKDs. The Template for Intervention Description and Replication (TIDieR) was used to extract intervention components and characteristics. Risk of bias was assessed. A narrative synthesis was deployed.

Results: Searches retrieved 3027 studies. Thirty-four full texts were reviewed with 14 included. Interventions reporting positive PA outcomes all contained: exercise and behavioural change components, delivery by health care professionals, 13 or more exercise sessions, individual tailoring, and assessment of adherence.

Conclusions: The TIDieR framework creates standardisation to understand PA interventions for people with MSKDs. To ensure interventions meet the needs of populations, there is need to improve implementation design and understand which BC components are the most optimal.

> IMPLICATIONS FOR REHABILITATION

- Musculoskeletal disorders (MSKDs) create a widespread and debilitating impact on individuals and health and care systems.
- Physical activity (PA) interventions are recommended to support improvement and coping of MSKD; however, the components and characteristics of these interventions are unclear.
- There are common characteristics and components of successful interventions supporting PA in MSKD such as delivery by health care professionals, tailoring, assessment, and addressing of adherence.
- Improvements in underpinning implementation planning and theory are required.

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KEYWORDS
Musculoskeletal; physical activity; interventions; characteristics; components; TIDieR

Background

Musculoskeletal disorders (MSKDs) (disorders of the bones, muscles, or joints) are the second most common cause of disability worldwide [1]. MSKDs place significant burden on individuals, health services and society, with low back pain (LBP) alone causing the most years lost to disability out of any condition [2]. The prevalence of MSKDs is rising globally [3], with a suggested range of contributory factors including, work related issues [4], co-morbidities [3], and difficulty in engaging in physical activity (PA) [5].

Supporting transition to increased PA is an important strategy in helping people with MSKDs to decrease the burden of their condition [6,7] whilst improving general health [8]. Despite the known benefits, patients with MSKDs find transition to increased PA difficult [9], which is compounded by inconsistent focus in clinical practice in promoting PA in MSKDs [10].

A range of complex interventions have been used to support people with MSKDs to transition to PA [11–13]. By their very nature, complex interventions include several components, a range of targeted behaviours, and differing skills required by those delivering and receiving the intervention [14]. Behavioural change techniques (BCTs) are a well-established component of these interventions [15,16]. BCTs are "observable, replicable, and irreducible components of an intervention designed to alter or redirect causal processes that regulate behaviour" [17]. Although BCTs are

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identified and advocated components of PA interventions in MSKDs, it remains difficult to understand which actual components are most effective. This is due to the complexity of these interventions and the identification of the "active ingredients" of the intervention [17]. There remains a disconnect between the strength of evidence for these and the ability to reproduce them in practice [9,17].

Systematic reviews have considered components and characteristics of interventions aimed at optimal PA for MSKDs [18–20]. They commonly show that studies often fail to clearly articulate concepts of treatment fidelity [21], and do not report the detail of intervention approaches required to support standardised replication [20]. To overcome this, the Template for Intervention Description and Replication (TIDieR) framework [22], developed by extensive and robust Delphi methods, provides a standardised approach to reporting the components and characteristics of interventions. It has been used in a range of interventions such as post-partum weight management [23], diabetes prevention [24], mental health conditions [25], and for older adults [26].

Searching of the International Prospective Register of Systematic Reviews (PROSPERO), and other relevant databases, has revealed no systematic review using the TIDieR framework to systematically review the components, characteristics, and fidelity of interventions that aim to support PA uptake in MSKDs.

This systematic review used the TIDieR framework to undertake a standardised extraction of intervention characteristics and components. This uniquely provides consistent understanding of PA intervention design for MSKDs, whilst also demonstrating where key gaps in intervention design and report are occurring.

Methodology

Details of the protocol for this systematic review were registered and can be accessed at the PROSPERO [27]. A systematic search of the literature followed guidance from the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [28] and the Cochrane handbook for systematic reviews of interventions [29]. A structured extraction of intervention components and characteristics from the resulting studies, using the TIDieR framework was also undertaken, with reference to Cochrane [29] and PRISMA [28]. This review used a broad definition of MSKDs. The broader scope was applied as whilst different pathophysiological mechanisms underpinning different MSKDs exist, increased PA will likely support improvement across all MSK conditions.

Systematic search of the literature

A search strategy (supplementary file 1) was applied to three databases – MEDLINE (EBSCO), CINAHL (EBSCO), and SportDiscus (EBSCO) from 2009 to February 2023. The lower data range limit was set to retrieve studies only after the first publication of the Medical Research Council (MRC) guidelines for complex interventions in 2008 [30].

Inclusion and exclusion criteria

Studies were included if they were randomised controlled trials (RCTs) that investigated (1) people over the age of 18 living with an MSKD, (2) an exercise or PA intervention that explicitly aimed to increase PA in participants – defined by having outcomes to measure change in PA due to the intervention, (3) outcomes related to PA level as either a primary or secondary outcome and (4) were published in a peer-reviewed journal. Studies were excluded if they were not RCTs published in a peer-reviewed journal, investigated populations without MSKDs, or were published in languages other than English. Papers that did not explicitly measure PA were also excluded.

Screening

Citations were exported from RefWorks citation manager to an Excel spreadsheet. Two authors (AT, AR) screened titles, abstracts, and full-text articles. Any non-concordance that could not be resolved between the two reviewers were discussed and a consensus reached; any outstanding disagreements were resolved using a third author (SM). Reasons for exclusion were recorded.

Data extraction

A data extraction form, based on the categories set out in the TIDieR framework was used to collect data about intervention characteristics and components. Descriptive study and population characteristics were collected, along with adverse incidents. The form was piloted with two authors (AR, AT) to check concordance with extraction. Any non-concordance was discussed and resolved. One author (AT) conducted the remainder of the extraction.

Risk of bias assessment

The risk of bias (RoB) 2 tool [31] was used to assess study quality. It assesses RoB in five domains. (1) Bias arising from the randomisation process, (2) bias due to deviations from intended interventions, (3) bias due to missing outcome data, (4) bias in measurement of the outcome, and (5) bias in selection of the reported result. Risk of bias in each domain is assessed as either low risk, having some concerns or high risk, with guidance to support reviewers in making these decisions. Overall RoB reflects the highest risk rating found in any of the five assessed domains.

The RoB 2 tool was piloted on three studies by two authors (AT, AR) to gain consensus on how to use the tool and on outcome of the RoB assessment. The remainder studies were rated by one reviewer (AT) and checked by a second reviewer (AR). Any non-concordance was planned to be decided by a third author (SM); however, this was not required.

Synthesis

Narrative synthesis was used to summarise the results from the studies. The narrative was based on the TIDieR framework, with comparison of findings based on each of the TIDieR domains. A sub-group of interventions that reported effectiveness was assessed to understand common components or characteristics within this group, again as defined by the TIDieR framework domains. Meta-analysis was not deemed appropriate for this systematic review as the key aim is to extract and understand the components of PA interventions and not to understand their benefits and harms.

Results

Study selection

An overview of searches and screening are provided in Figure 1. Searches produced 3027 records of which 165 were duplicates,

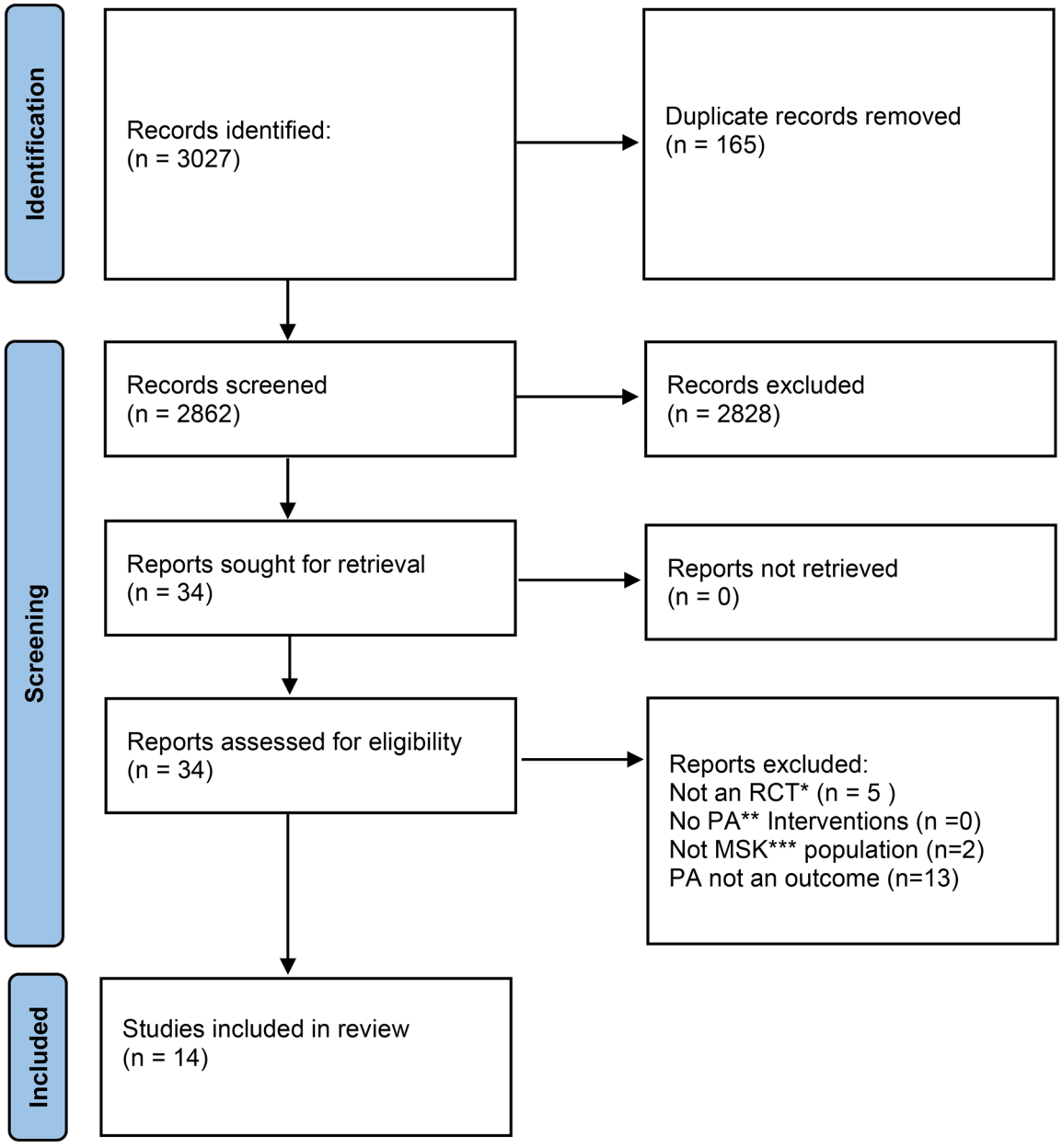

Figure 1. PRISMA [32] diagram of search results.
*RCT=Randomised Controlled Trial, **PA=Physical Activity, *** MSK=Musculoskeletal

leading to 2862 records being screened. Thirty-four publications were included for full text screening. This resulted in 14 studies deemed appropriate for data extraction.

Risk of bias assessment (Figure 2)

Overall, seven studies [33–38] were assessed as low RoB, five [39–43] with some concerns and two [44,45] with high RoB. High risk in both studies was due to outcome assessors not being blinded to intervention in the "measurement of the outcome" domain. Six studies had "some concerns" in the "selection of the reported result" domain due to lack of clarity if analysis was undertaken in accordance with pre-specified plans and the use of multiple outcome measures for one outcome domain.

Study characteristics

Seventeen interventions were found in the 14 studies that met the inclusion criteria (three studies [34,38,39] each had two intervention arms). There was a range of MSKDs reported across the 14 studies. Four studies included knee osteoarthritis (OA) [37,39,41,42], one hip and knee OA [37], and another included rheumatoid arthritis (RA) [41], whilst one included RA only [46]. Three studies included LBP [33,38,43], one LBP and hip pain [45]. Two studies included post hip fracture [36,40], one post-total hip arthroplasty [35] and one osteoporotic fracture [34]. Finally, one study included participants post-discharge for any MSK disorder [44].

In total, there were 1487 participants in intervention groups across 14 studies. Studies were undertaken in Europe (n = 9)

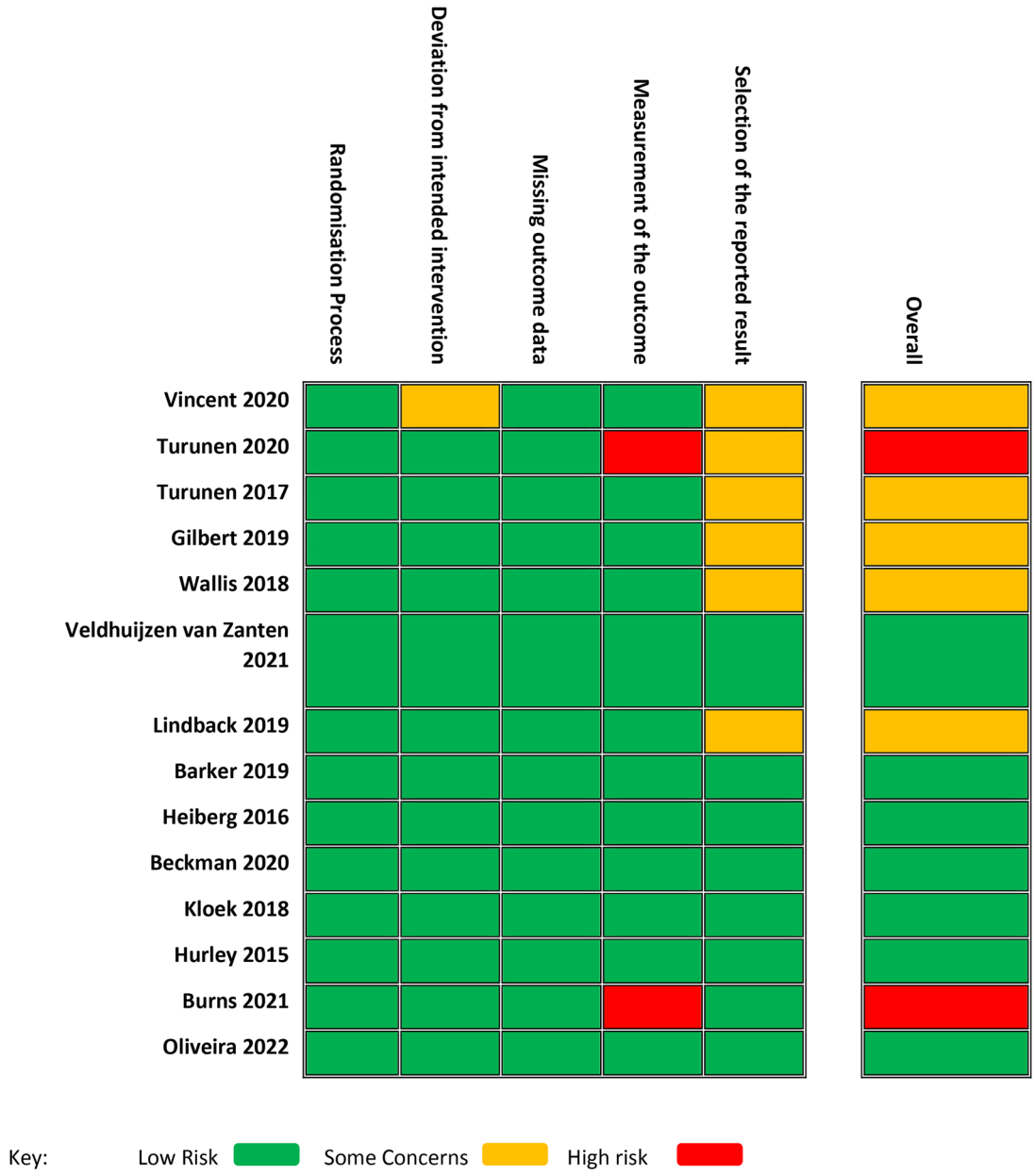

Figure 2. Risk of bias assessment [31].

[34–38,40,43,44,46], the USA (n = 3) [39,41,45], South America (n = 1) [33], and from Australia (n = 1) [42].

All studies had a control group arm (n = 1187 participants). There was a range of control interventions: Four studies [40,42–44] used usual care consisting of a mix of rehabilitation, physiotherapy, information giving and pharmacological management. Four applied controls of physiotherapy care [36–38,45]. Other control groups were advice to stay active [35], a single session of physiotherapy [34], gym and home based exercise [46], one session of counselling [41], one of group exercise and modified coaching sessions [33], and normal activities (no further information given) [39]. The term physiotherapy care/treatment does include a range of approaches, the term is used in this review as it is reported by interventions. Physiotherapy is defined as helping people affected by injury, illness or disability through movement, manual therapy, education, and advice [47].

Participant characteristics

Of the total 2674 participants, 1853 were female and 821 were male. Age ranges varied; six studies recruited adults aged 50 or over [35,36,39,40,42,44], four studies recruited 18 years old or over [34,41,45,46], and four studies specified age ranges: 25–80 [43], 40–80 [37], 18–60 [33], and 18–65 [38].

Recruitment was varied. Four studies recruited from physiotherapy clinics [33,37,38,45], two recruited participants admitted for elective orthopaedic surgery [35,40], two from orthopaedic clinics [39,42], two from rheumatology clinics [41,46], one from a spine clinic [43], one following notes review of participants admitted for an MSK disorder [44], and one from a nursing home [36]. Two studies [39,41] also recruited from clinical trials registers, with one study also using public adverts [41]. The depth of information provided regarding patient characteristics varied across studies data (Table 1).

Table 1. Participant characteristics reported in the included studies.

	Eth	Ed	CoM	We	SC	Emp	Mar	Smo	BMI
Vincent and Vincent [39]	●		●						●
Turunen et al. [44]		●	●				●		●
Turunen et al. [40]			●						●
Gilbert et al. [41]	●	●				●		●	●
Wallis et al. [42]						●			●
Veldhuijzen van Zanten et al. [46]			●				●		●
Lindbäck et al. [43]						●		●	
Barker et al. [34]			●						●
Heiberg et al. [35]		●					●		
Beckmann et al. [36]		●	●				●		●
Kloek et al. [37]		●	●						●
Hurley et al. [38]		●	●		●	●		●	●
Burns et al. [45]	●	●							●
Oliveira et al. [33]		●				●			●

Eth: ethnicity; Edu: education status; CoM: co-morbidities; We: wealth; SC: social class; Emp: employment; Mar: marital/living arrangements; Smo: smoking; BMI: weight/BMI.

Table 2. Physical activity interventions and outcome measures in the included studies.

Study	Intervention	Control	PA outcome measure	Validity and reliability?	Measure
Vincent and Vincent [39]	Eccentric/concentric exercise	Normal activity	Accelerometer (StepWatch)	Yes [48]	Mean daily ambulation steps
Turunen et al. [44]	Motivational interviewing and rehab	Physiotherapy, information, medication (standard care)	Accelerometer (Hookie AM20 Activity Meter)	Unclear	Total PA, min/day
Turunen et al. [40]	PA counselling and rehab	Physiotherapy, information, medication (standard care)	Modified Grimby Scale	Yes [49]	Number mod/heavy PA in preceding month on scale of 1–7
Gilbert et al. [41]	Counselling and motivational interviewing	Brief physician counselling	Accelerometer (GT1m ActiGraph)	Yes [50]	Mean daily activity minutes
Wallis et al. [42]	Walking and planning/social support	Physiotherapy, information, medication "usual care"	Accelerometer (ActivPAL)	Yes [51]	Mean number of steps/days
Veldhuijzen van Zanten et al. [46]	Autonomous motivation and exercise	Home and gym based exercise	International PA Questionnaire (IPAQ)	Yes [52]	Mod-vigorous PA, min/week
Lindbäck et al. [43]	Physiotherapy and goal setting	Advice and usual rehabilitation	Non-standardised outcome measure	Unclear	% Mod/very active (self-report) PA past 12 months
Barker et al. [34]	Exercise/manual therapy	Single session of physiotherapy	PA Scale for the Elderly (PASE)	Yes [53]	Activity levels in previous week
Heiberg et al. [35]	Walking	Advice to stay active, self-managed exercise	University of California Los Angeles activity scale (UCLA)	Yes [54]	Mean score on scale of 0–10
Beckmann et al. [36]	Exercise	Usual physiotherapy care	University of California Los Angeles activity scale (UCLA)	Yes [54]	Mean score on scale of 0–10
Kloek et al. [37]	Physiotherapy and goal setting	Usual physiotherapy care	Short Questionnaire to Assess Health Enhancing PA (SQUASH), Accelerometer (ActiGraph GT3x)	Yes [55] Yes [50]	SQUASH, min/day Accelerometer, min/day
Hurley et al. [38]	Walking/exercise and goal setting/repetition	Usual care physiotherapy	International PA Questionnaire (IPAQ)	Yes [52]	Number in IPAQ high group, %
Burns et al. [45]	Physiotherapy	Low back pain treatment	Godin–Shephard Leisure Time PA Questionnaire	Yes [56]	Number insufficiently active
Oliveira et al. [33]	Coaching and activity monitor	Supervised group based exercise	Baecke Habitual PA Questionnaire, Accelerometer (ActiGraph GT3x)	Yes [57] Yes [50]	Baecke Mean Score, scale of 3–15 Accelerometer, counts/min

Outcome measures (Table 2)

PA outcomes were measured both subjectively and objectively. Ten studies applied subjective PA measures. Of these, two [38,46] used the International PA Questionnaire (IPAQ) [52], two [35,36] the University of California Los Angeles activity scale (UCLA) [54]. One [40] the Modified Grimby Scale [49], one [34] the PA Scale for the Elderly (PASE) [53], one [37] the Short Questionnaire to Assess Health Enhancing PA (SQUASH) [55], one [45] the Godin–Shephard Leisure Time PA Questionnaire [56], and one [33] the Baecke Habitual PA Questionnaire [57]. One study [43] used a non-standardised questionnaire. In six studies [33,37,39,41,42,44], accelerometers were used to measure PA objectively. Analysis/critique of the psychometric testing of each outcome measure is out of scope, but we have identified studies in the wider literature that have undertaken validity/reliability review of each outcome measure (Table 2).

Intervention effectiveness

Overall, only two (12%) [40,43] of the 17 interventions in this review did help to improve PA in MSKDs, with both interventions showing between group changes. One intervention [37] reported no significant between group change but did show a statistically significant difference within the intervention group. Four interventions [38,42,44,46] reported positive between group trends; however, no statistical significance was demonstrated. Ten out of

the 17 interventions reported no statistically significant between group change, within group change or positive trends in PA [33–36,38,39,41,45].

TIDieR framework

The following sections set out the characteristics and components of interventions aligned to the TIDieR framework domains. These are summarised in Table 3.

Study aims (why)

All studies provided justification of why the intervention was undertaken. Justification based on gaps in evidence or policy requirements and the need to improve the support for MSKDs was presented by all studies. Only one study provided theory as justification for the intervention [46], which was assessing the effectiveness of self-determination theory.

Study design (what)

Interventions consisted of either PA/exercise and/or behavioural change (BC) approaches. Nine studies [33,37,38,40,42–46] focused on interventions with both PA/exercise and BC components. Within four studies, interventions were PA/exercise interventions alone [34–36,39]. One study used only a BC approach [41]. Studies applying exercise/PA components to interventions applied this in diverse ways. Walking was used in three interventions [35,38,42], two applied physiotherapy [43,45] and one focused on eccentric vs. concentric exercise [39]. Two studies applied a home-based PA and rehabilitation programme [40,44]. One study had a cardiovascular exercise programme [46], one a graded exercise programme [34], one an e-exercise programme [37], one a functional exercise programme [36], and one a supervised group exercise intervention [33]. Specific BC approaches used were motivational interviewing [41,44], PA counselling/coaching [33,40,41], goal setting/planning [37,38,42,43], and autonomous motivation [46].

Study interventionists (who)

In 12 studies, interventions were delivered by health care professionals – 10 by physiotherapists [33–35,37,38,40,42–45], one by physicians [41] and one by nurses [36]. In the remaining two studies, one intervention [46] was delivered by exercise professionals and BC/psychology professionals. It was unclear in a further study [39] who delivered the intervention.

Mode of intervention delivery (how)

There was variation in intervention delivery. Two interventions were delivered as group-based interventions [35,38]. Seven interventions [34,37,39–41,44,45] were delivered individually, where the participant received the intervention in a one-to-one session with the professional. Three further interventions had group and one-to-one elements [33,42,46]. In two studies, it was not explicitly stated if delivery was as a group or one-to-one intervention [36,43]. In 11 studies, interventions were face-to-face [33–36,38–46], with three of these interventions [38,41,46] also having a telephone contact element. One study [37] was delivered as an online programme.

Intervention setting and context (where)

Intervention setting varied between health (hospital, clinic, general practitioner), home/community, and exercise/gym. Nine interventions were delivered in health settings [34–36,38,39,43,45]. Two interventions [40,42] were in the persons home or in the community near their home. Five interventions had both health and home/community settings [33,37,38,41,44]. One intervention [46] was solely delivered in an exercise/gym environment.

Duration and frequency of intervention (when and how much)

Duration of interventions was reported by all studies. Seven studies delivered interventions which were less than three months in duration [34–38,42,43]. Three [39,40,44] were between three months and 12 months duration and two lasted for more than 12 months [41,46]. The number of sessions over the intervention duration was reported in all studies. Five interventions [34,35,41,42] delivered 6–13 sessions, 11 interventions [33,36–40,43,44,46] had more than 13 sessions. The minimum number of sessions intended across all studies was six sessions.

Intervention tailoring (tailoring)

All studies reported methods of tailoring in each intervention. All involved judgement in adjusting interventions, and in supporting individuals to goal set. Seven interventions [36,38,39,42,43] stated using the Borg scale of perceived exertion [58] to tailor exercise effort. One intervention [36] used pre-determined exercise progressions to support exercise tailoring.

Adherence assessment and planning (how well (planned))

Adherence was reported as being assessed in all but four studies [35,36,39,45]. Adherence was assessed by health professionals logging number of sessions attended or completed. Four interventions also asked participants to keep exercise diaries to support assessment of adherence monitoring [38,40,42,44]. Strategies were reported to support adherence reported in all but two studies [39,45].

Adherence to intervention (how well (actual))

Where studies reported adherence to the intervention, six interventions had 50.1–75% adherence [33,38,40,42–44], and two found 75.1–100% levels of adherence [37,38]. There were no studies reporting less than 50% adherence. Adherence levels were unclear in three interventions [34,46], and six interventions [35,36,39,41,45] did not report adherence rates. These studies reported attrition (dropouts) from the intervention or outcome measurement but were not clear on how much of the intervention participants were exposed to or not.

Adverse incident reporting

To understand intervention safety and delivery, the Cochrane handbook of systematic reviews [29] states the need to include any adverse incidents and how they are reported in interventions. Six studies [34,35,38,42,44,45] reported a prospective intention to monitor and record adverse incidents in intervention design. In one of these studies [42], a minimal adverse incident (increased

pain due to trial intervention) occurred. Three further studies [36,41,43] did not include capturing of adverse incidents in the intervention design; however, they did report if an adverse incident had occurred or not in their results. Five studies did not mention adverse incident monitoring or occurrence [33,37,39,40,46].

Components of successful PA interventions (Table 4)

A key aim of this study is to understand characteristics of studies that demonstrated positive impact on PA. Table 3 provides a detailed breakdown of components for both successful and unsuccessful interventions. Three studies demonstrated statistically significant improvements in PA levels, two showing between group improvement, compared to control [40,43] and one showing within group pre/post improvement [37]. These interventions all have the combination of the following characteristics and components in common: joint exercise/PA and BC interventions, delivered by health care professionals, had greater than 13 sessions, tailored sessions to participants needs (though this was the only common theme throughout all studies), adherence is assessed, and strategy to improve adherence is undertaken. Table 4 shows further detail of the combination of components of these successful interventions.

Discussion

This review sought to identify components and characteristics of interventions that aim to increase PA in MSKDs and to clarify which characteristics and components are present in reportedly successful interventions. This is the first review to adopt the TIDieR framework to extract data on intervention components and characteristics about PA interventions in MSKDs. This builds on previous reviews in this field [18,20]. Using a recognised extraction template was important to ensure a standardised and comprehensive approach to reporting, which provides replicability for interventions in practice [59]. Inherent to this is that gaps in description/design of interventions are found. For further studies investigating intervention characteristics and components, we recommend the use of a standardised approach such as using the TIDieR framework.

All interventions in this review, including those reporting successful impact on PA status, demonstrated inconsistent and frequently poor reporting, with intervention design lacking consistency and standardisation. This included lacking a theoretical underpinning for interventions, which is advocated by guidelines [14] to support development of programme theory for complex interventions such as PA interventions for MSKDs. Other reviews report similar issues of poor reporting quality in exercise interventions across healthcare [60,61] leading to challenges in reproducibility in practice [61].

Participant characteristic reporting in studies within this review was particularly inconsistent. This is important as defining participant characteristics shows who is being exposed to the intervention, which provides evidence of who may or may not benefit. Especially key is understanding characteristics that lead to health inequalities, for instance, studies consistently applied inconsistent and broad groups of ethnicity categories.

Intervention design

This review has found that variability in intervention design and reporting continues despite guidance existing for several years to support the design of these complex interventions [30]. Implementation of PA interventions on broader populations is also lacking in standardisation [62], with inconsistent use of implementation science or planning to underpin interventions design, which is reflected in this review. There are calls in the literature for guidance for researchers of how to plan implementation effectively [63].

Recent updated MRC guidance has given further clarity on what should be considered when designing complex interventions [14]. This framework is based on core elements of understanding context, develop, refine, and test programme theory, engaging stakeholders, identifying uncertainties, refining interventions, and considering economic factors [14].

Implementation approach within a healthcare system is also important to understand, so benefits/costs can be tailored to specific populations. Using a joint strategic needs assessment (JSNA) and defining the support for MSKDs across a health and care system is recommended [64]. In addition, best practice suggests using a population heath approach to apply a continuum of interventions based on the level of intervention needed by MSKDs [64].

There is a growing foundation of guidance and recommendations to support implementation design of PA interventions for MSKDs, this includes considering interventions within the real world, i.e., the context of the health and care systems that they will be applied in.

It is essential that studies considering effectiveness of interventions to support uptake of PA in MSKDs adopt standardised approaches to intervention design to improve transparency and reproducibility into wider spread clinical practice.

Components and characteristics

This review found a range of components and characteristics throughout all interventions. As mentioned however, six components were all common in the reportedly successful interventions.

BC and exercise components were present and applied in all effective interventions. This concurs with systematic reviews of effectiveness of PA interventions [18,20] where BC components are routinely found in effective interventions. The BC components found in successful interventions in this review are all described in a consensually agreed taxonomy of 93 BCTs [17]. These successful components are also broadly in agreement with a review undertaken of determinants of adherence to self-management and home exercise [65].

Although there are identified exercise and BC components in the literature, there remains a significant issue of understanding which are most effective, which are not effective and what is the optimal combination of PA and BC components and in which circumstance. This review has shown components of successful interventions. More research is needed to understand combinations of PA and BC components effectiveness and how they map to underpinning theory.

Tailoring was a unanimous component in all interventions in this review whether effective or not. This is concordant with other reviews that support the use of tailoring of programmes to individuals [66] and in frameworks specifying minimum standards of care for commissioners, providers, and practitioners [67]. Tailoring in interventions appears to be a non-negotiable component, essential to all PA interventions for MSKDs.

Measuring and supporting adherence is a key component of PA interventions for MSKDs [68,69]. In this review, 12 out of 17

Table 3. Description of physical activity interventions based on the TIDieR framework.

Author and country	Intervention	MSK condition	Outcome	Study aims (why)		Study design (what)			Study interventionalist (who)			Mode of intervention delivery (how)		
			PA	Theory	Justification but no theory*	Exercise/ PA	BC	Exercise/ PA and BC	Psy/ Coun	HCP	Exercise prof	Group	Individual	Telephone
Vincent and Vincent USA [39]	Eccentric exercise	Knee OA	x		●	●				≈			●	
Vincent and Vincent USA [39]	Concentric exercise	Knee OA	x		●	●				≈			●	
Turunen et al. Finland [44]	MI and rehab	Lumbar and lower limb	≈		●			●		●			●	
Turunen et al. Finland [40]	PA counselling and rehab	After hip fracture	√√		●			●		●			●	
Gilbert et al. USA [41]	Counselling and MI	Knee OA or RA	x		●		●			●			●	+
Wallis et al. Australia [42]	Walking and planning/ social support	Knee OA	≈		●			●		●		+	●	
Veldhuijzen van Zanten et al. UK [46]	Autonomous motivation and exercise	RA	≈	●				●	●		●	+	●	+
Lindbäck et al. Sweden [43]	Physiotherapy and goal setting	LBP	√√		●			●		●			Δ	
Barker et al. UK [34]	Exercise	Osteoporotic fracture	x		●	●				●			●	
Barker et al. UK [34]	Manual therapy	Osteoporotic fracture	x		●	●				●			●	
Heiberg et al. Norway [35]	Walking	After THA	x		●	●				●		●		
Beckmann et al. Norway [36]	Exercise	After hip fracture	x		●	●				●			Δ	
Kloek et al. Netherlands [37]	E-exercise and goal setting	Hip and knee OA	√		●			●		●			●	
Hurley et al. Ireland [38]	Walking and goal setting/ repetition	Chronic LBP	≈		●			●		●		●	+	+
Hurley et al. Ireland [38]	Exercise and goal setting/ repetition	Chronic LBP	x		●			●		●		●		
Burns et al. USA [45]	Physiotherapy	Chronic LBP and hip pain	x		●			●		●			●	
Oliveira et al. Brazil [33]	PA coaching and activity monitor	Chronic LBP	x		●			●		●		●	+	

(●) reported; (Δ) unclear – some mention but not clearly defined; blank: not reported; (+) adjunct to main intervention; (√√) statistically significant between
MI: motivational interviewing; BC: behavioural change; Psy/Coun: psychologist/coun; PA: physical activity; OA: osteoarthritis; RA: rheumatoid arthritis; LBP:

		Intervention setting (where)			Duration and frequency of intervention (when and how much)						Tailoring	Adherence assessment and planning (how well (planned))		Intervention adherence (how well (actual))			
					Duration			No. of sessions						Actual adherence (%)			
In person	Digital	Health	Home/ community	Exercise	≤3 months	>3 months	≥12 months	1–5	6–13	>13		Adherence assessed	Strategy used to improve adherence?	≤25	25.1–50	50.1–75	75.1–100
•		•				•				•	•						
•		•				•				•	•						
•		+	•			•				•	•	•	•			•	
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group effect; (√) statistically significant within group effect (not SS improvement compared to control); (≈) non-statistically significant trend; (x) no significance; low back pain; THA: total hip arthroplasty; HCP: healthcare provider. *No underlying theory defined to base aims on

Table 4. Common components and characteristics of effective interventions.

Common key characteristics/ components of reported successful interventions	Kloek et al. [37]	Turunen et al. [40]	Lindbäck et al. [43]
Intervention components	e-Exercise programme, behavioural graded exercise	Home based exercise programme, with physical activity counselling (motivational interviewing)	Tailor made general supervised exercise programme, behavioural approach for fear avoidance and activity levels
Mode of delivery	Delivered by physiotherapists	Delivered by physiotherapists	Delivered by physiotherapists
Number of sessions	Mix of face to face and structured e-learning	Face to face and home based	Face to face and home exercise
Tailoring of interventions	Automatic tailoring provided	Individual tailoring occurs at telephone/face to face sessions	Individualised prescription of exercise provided
Adherence evaluation	Via website visits, online progress reports	Exercise diary used	Logbooks complete by participants
Strategies to maximise adherence	Automated emails, face to face discussion of PA maintenance strategies	Encouragement during telephone, face to face sessions	Physiotherapist encouragement

(71%) interventions assessed adherence, including all effective interventions. This contrasts with another review that found adherence assessment in only 47% of interventions [70]. Key evidence-based determinants of adherence in MSKDs have been identified in the literature as self-efficacy, social support, and task appreciation [65]. Approaches to measuring adherence have been developed, such as a six-item Adherence to Exercise for Musculoskeletal Pain Tool (ATEMPT) [71]. The incomplete uptake of adherence measures in interventions is concerning given the importance of adherence as a component and the evident research that exists to support adherence. Measuring and instigating strategies to address adherence are essential components in PA interventions for MSKDs.

Fourteen – including all effective interventions – of the 17 interventions were led by health care professionals. This predominance of health care providers (mainly physiotherapists) does reflect the situating of PA interventions in MSKDs in health care settings and is in concordance with another review investigating PA interventions in primary care, where nurses undertook delivery [72]. Only one study in this review was exercise professional led, which is a key feature of other PA interventions. Another intervention found in the literature, was an NHS trust wide PA intervention, led by sports and exercise medicine consultants [73], with another joint health and public health intervention for MSKDs being led by PA instructors [74]. However, considering different staff groups separately maybe too simplistic. Guidelines advocate for a multi-disciplinary approach to ensure that individualised, tailored interventions are applied [75]. Creating a coalition of the willing is essential [73] to ensure interventions have the appropriate professionals to support people with MSKDs.

All effective interventions in this review exposed participants to 13 or more sessions. This level of dosage is consistent with a large umbrella review, which found 3–4 sessions a week for up to 17 weeks demonstrated small to large effect sizes for exercise interventions in MSK pain [76].

The reality in PA interventions is likely that the combination and interaction of differing components are likely to influence participants' PA outcomes and experience. By nature, these interventions are complex, which should be considered at the outset when considering intervention design [14] and complexity should be embraced [73], understanding and investigating the interaction of differing components is required rather than considering components in isolation.

Strengths and limitations

This review has followed recognised systematic review guidelines, the TIDieR framework, a robust quality assessment tool and multiple reviewers to support development, conduct and reporting.

The use of the TIDieR framework does provide a standardised, reproducible approach to intervention component analysis. A strength is the opportunity to adapt TIDieR in response to the needs of an individual study. However, this subjectivity does lead to TIDieR application in diverse ways [77,78] that could lead to non-standardisation if repeating a review.

In some studies, "Physiotherapy" or "Physical Therapy" was used to describe an intervention or a control group. This is a common approach in interventions; however, it can lead to ambiguity as physiotherapy is also a profession. We have taken any intervention or control group described as physiotherapy or physical therapy as an exercise or pa intervention that is delivered by a physiotherapist.

This review used a broader definition of MSKDs than other reviews, which have focused on mainly lower limb MSK pain [20] or non-surgical MSK conditions [19]. The broader scope in our review was applied as whilst different pathophysiological mechanisms underpinning different MSKDs exist, increased PA would support improvement across all the conditions. This broad choice was also taken as PA interventions could be devised that are tailored to the needs of different MSKDs at the same time. This is both more economical and viable for such interventions in practice.

As with any systematic review, there is possibility of studies not being retrieved that could have been included. Broader searches of databases could have taken place, and more databases could have been searched. However, the findings from this review are similar with other reviews that have considered PA interventions.

Conclusions

This review has shown that intervention design and descriptions in PA interventions for people with MSKDs remain inconsistent. Few studies align to recommendations on intervention design [14] and many do not consider the nuances in context of the health and care system in which they will be delivered. There is a critical need for PA interventions in MSKDs to be designed based on evidence-based foundations such as implementation science guidance and be applicable for the populations they will serve.

Policy guidelines state that PA is beneficial to reduce the burden of MSKDs and people should be supported to make the transition to PA. This review systematically demonstrated which components and characteristics are being used in interventions to support PA uptake in people with MSKDs. These PA and BC components are consistent with other research. It has also found that there are characteristics that are common to successful PA interventions. These are: exercise and BC components, delivery by healthcare professionals, have 13 contacts or more, interventions are tailored to individual need, adherence is assessed and strategies to improve adherence are undertaken.

For researchers, this review informs future interventions, considering what could be an optimal design and provide a structured approach to use in the future for understanding intervention characteristics and components. It also highlights the need to investigate which PA and BC components and in which combination is most effective. For clinicians' direction is provided for what components and characteristics should be used in exercise and PA interventions in practice. For people with MSKDs, this work supports understanding of what to expect when encountering this type of intervention.

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