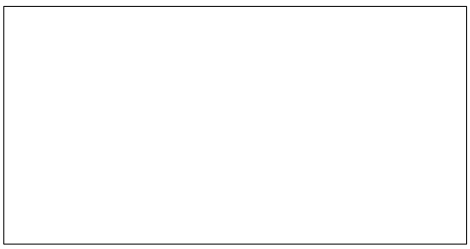

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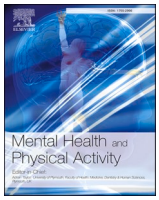

Increasing activity and reducing sedentary behaviour for people with severe mental illness: what are the active ingredients for behaviour change? A systematic review

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ABSTRACT

Increasing physical activity (PA) and reducing sedentary behaviour (SB) can improve health outcomes and reduce rates of premature mortality for people with severe mental illness (SMI). In this systematic review we aimed to explore the active ingredients of existing PA interventions for people with SMI. We reviewed intervention functions, behaviour change techniques (BCTs), contextual features and underpinning theories. We included 15 PA interventions, of which 4 were classed as effective (effect size >0.273). We identified the frequency of intervention functions and BCTs that were used in each study and compared the number of effective studies that featured a particular BCT or intervention function with the total number that featured those components. We used the TIDieR checklist to document contextual features that might be important within effective interventions including the theories that guided the development of interventions. The most frequently used functions were education and environmental restructuring, both of which were identified in effective interventions. The BCTs that were identified as potentially useful were framing and reframing, feedback on behaviour and self-monitoring. No discernible contextual features were unique to the effective interventions, but combinations of some features seemed to be (PA tracking, educational components and support delivered by community health teams). More high quality and better reported studies are required to strengthen this evidence base.

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1. Introduction

People who live with severe mental ill health (SMI), including schizophrenia and bipolar disorder, die on average 10–20 years earlier than those without SMI (Hayes et al., 2017). The majority of these deaths are attributed to preventable physical health conditions such as cardiovascular disease and type 2 diabetes (Correll et al., 2017; Hoang et al., 2013). In the wider population, there is robust evidence that higher physical activity (PA) behaviour and lower levels of sedentary behaviour (SB; defined as any waking behaviour expending energy at a rate ≤1.5 metabolic equivalents while in a sitting, reclining or lying posture (Tremblay et al., 2017)) can reduce the incidence of these diseases (Naci & Ioannidis, 2013). There is also a growing body of evidence to suggest increasing levels of PA among people with SMI can also

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reduce the risks of these conditions, alongside other benefits such as reductions in the severity of depressive and schizophrenic symptoms, and improved quality of life (Rosenbaum et al., 2014; Stubbs et al., 2018; Vancampfort, Rosenbaum et al., 2017; Vancampfort, Firth et al., 2017). However, a global meta-analysis found that people with SMI engage in 38.4 min of moderate to vigorous activity (MVPA) per day, compared with 47.6 min per day in individuals without SMI. Furthermore, they are less likely to meet UK Government guidelines of 150 min MVPA per week (Vancampfort, Rosenbaum, et al., 2017). They also experience unique barriers that prevent them from engaging in PA, such as increased mental health symptoms, lack of social support, the side effects of medication, tiredness and reduced motivation (Tew et al., 2023).

Behavioural interventions are required that promote regular PA among this group. Whilst there is a profusion of studies of complex interventions in this space, there is little evidence of effectiveness, in part because research to date has been of low quality due to small sample size and poor quality of reporting. A 2018 review of the outcomes of controlled and uncontrolled trials that were designed to increase levels of PA in people with SMI found low-quality evidence of a benefit in 7/16 controlled studies and no improvement in 3/16 controlled studies (Ashdown-Franks et al., 2018). A more recent systematic review performed by the authors of this paper identified 11 unique randomised controlled trials (RCTs) of interventions, of which three were deemed to have been effective at increasing levels of PA (an effect size of >0.273 was classed as effective) (Peckham et al., 2023).

Previous reviews have not examined the content or contextual features of identified interventions in sufficient detail. To better understand which elements of intervention *content* contribute to intervention effectiveness, a theory-informed approach is beneficial. Such approaches can elucidate the mechanisms through which interventions operate, identifying theoretical constructs that are consistently associated with positive outcomes. This can support the design of future interventions that are both evidence-based and theoretically coherent.

The behaviour change wheel (BCW) provides a comprehensive framework for analysing and developing behaviour change interventions (Willett et al., 2019). It is grounded in the COM-B model, which proposes that behaviour (B) results from the interaction of three key components: capability (the individual's physical and psychological ability to perform the behaviour), opportunity (the physical and social environment that enables the behaviour), and motivation (the reflective and automatic processes that drive behaviour). According to this model, effective interventions must address one or more of these components to bring about behaviour change. Surrounding the COM-B system are nine intervention functions (e.g., education, persuasion, training, enablement), which represent broad strategies that can be used to influence the COM-B components. These intervention functions provide a practical bridge between theoretical understanding and real-world intervention design.

A novel review focused on describing the content of interventions aimed at improving PA and/or decreasing SB in SMI, including coding them based on BCW intervention function, could help to identify more clearly the broad approaches that could effectively promote PA within this population (Gardner et al., 2016).

The functions within the BCW can also be broken down into more specific behaviour change techniques (BCTs). For example, the intervention function 'education' incudes BCTs such as 'information about health consequences' and 'information about antecedents'. The Behaviour Change Technique (BCT) taxonomy (Michie et al., 2013) is a structured taxonomy of behaviour change techniques that was developed to provide a method for specifying intervention content. It has been used extensively in systematic reviews in other areas to identify reliably those BCTs that were associated with promising behavioural interventions. For example, previous systematic reviews of PA interventions have suggested that the number of BCTs and use of techniques such as self-monitoring and goal setting are associated with improved outcomes (Michie et al., 2009; Samdal et al., 2017; Willett et al., 2019). However, the effectiveness of specific techniques may vary according to the population being targeted (or context), and the techniques in PA interventions for people with SMI have not been evaluated.

Previous reviews of behaviour change interventions have taken one of three approaches to evaluate the potential usefulness of different intervention functions and BCTs (Howlett et al., 2022). These include meta-regression, or in cases in which meta-analysis is not possible, the calculation of a promise ratio or/percentage effectiveness. A promise ratio calculates the frequency of use of a specific component or technique in 'very' or 'quite' promising studies compared with its use in 'not' promising studies (Gardner et al., 2016). Studies are categorised as very promising if a significant difference is observed (on the outcome of interest) both within a group and between comparator groups, whereas studies that demonstrate a difference only within a group or between groups are categorised as quite promising (Gardner et al., 2016). The percentage effectiveness method, on the other hand, is a simple comparison of the number of effective studies that feature a particular component or technique with all of the studies that feature that technique (Martin et al., 2013). The latter approach may be useful in cases where an existing review has already classified an intervention as effective and where this classification differs from the original manuscripts (e.g. based on effects sizes using data provided by authors as was done in our recent review (Peckham et al., 2023).

Identifying both the broader intervention functions and the BCTs that are used within existing interventions, alongside their contextual features, could help to inform future interventions that would help people with SMI to increase their levels of PA and/or reduce their SB to ultimately improve their health outcomes.

This review aimed to build on, and complement, our earlier review of intervention effectiveness (Peckham et al., 2023) through using the Behaviour Change Wheel, BCT taxonomy (v1) and template for intervention description and replication (TIDieR) checklist (Hoffmann et al., 2014) to identify the intervention functions, BCTs and contextual features (including underpinning theories) that have been used to increase PA and/or decrease SB in people with SMI within published intervention literature. In doing so, this review addresses a critical evidence gap by providing a structured and theory-informed synthesis of how PA and SB interventions for people with SMI have been designed and reported, which is essential for informing future intervention development and replication.

2. Methods

The review included an updated search of the literature included in the previously published review focused on the effectiveness of interventions to increase PA or decrease SB in people with SMI (Peckham et al., 2023), to ensure the inclusion of any new, relevant studies given the time elapsed. However, the focus of this review is on intervention content and not effectiveness, as this was explored in the prior review. The protocol for this update was prospectively registered on the PROSPERO register of systematic reviews: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=541859. The review has been reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) 2021 statement (Page et al., 2021). The search strategy, eligibility criteria and study selection methods were aligned to those used in the previous review (with an extended date for the search) but are also included here for completeness.

2.1. Search strategy

An electronic search strategy that combined search terms for SMI, PA, SB and RCTs was used to search the following databases from their respective inception dates to June 2024: MEDLINE (PubMed), EMBASE, PsycINFO, NIHR Library, CENTRAL and CINAHL (see (Peckham et al.,

2023) for full strategy). Backward citation searching was conducted by inspecting reference lists of identified eligible studies.

2.2. Eligibility criteria

Eligibility criteria are reported in line with the Population, Intervention, Comparison, Outcome and Study (PICOS) framework (Centre for reviews and dissemination, 2006).

2.2.1. Type of participant/population

Participants were aged 18 or above and diagnosed with a SMI, which was defined in this review as schizophrenia or other psychotic disorders, bipolar disorder or depression with psychotic features. This classification is based on those that would appear on a UK Primary Care SMI database (NHS England, 2018). The diagnosis must have been made using the International Classification of Diseases (ICD) or Diagnostic and Statistical Manual (DSM) criteria. Studies that failed to specify this were excluded. Studies that included participants with SMI and other diagnoses were eligible if the reporting of the results enabled the extraction of data for participants with SMI, or if more than 70 % of participants had SMI, as indicated by descriptive statistics.

2.2.2. Type of interventions

Interventions that were designed to increase time spent in any form of PA or to reduce time spent in SB were included, with no limits on the duration, setting or content of the intervention.

Multi-component or multi-behavioural interventions (e.g., dietary modification or smoking cessation) were included only where change in PA or SB was one of the described intervention objectives.

2.2.3. Type of comparison

Passive control conditions were included; these might be treatment as usual, waiting list control or no treatment conditions. Active conditions were also included, such as alternative cognitive or behavioural approaches. Studies that failed to report a control condition or where two (or more) interventions were compared with neither described as a 'control', were not eligible for inclusion in this review.

2.2.4. Type of outcome measures

Studies that reported validated outcome measures of PA and/or SB were included. Eligible outcomes took the form of data that were collected either using devices (e.g. pedometers, accelerometers, or inclinometers) or questionnaires (i.e., self-reported data).

2.2.5. Types of studies

The studies were RCTs that were published in English and that targeted change in levels of PA or SB among people with SMI as one of the intervention objectives. Studies were eligible if they had been conducted in either in-patient or community settings.

2.3. Study selection

Two authors (EP and RB) performed the searches and all results were imported to Covidence (https://www.covidence.org/), a web-based screening and data extraction tool that is designed to assist the management of systematic reviews. Covidence was used to remove duplicates and screen the titles, abstracts and full texts of the articles.

Pairs of reviewers screened all titles and abstracts independently for relevance to the inclusion criteria (GTT, RB, GJ, LB, EB, TB, KM, KP, EP). Discrepancies were resolved by discussion and third-party arbitration. The same approach was used to screen the full texts that had been identified as potentially relevant according to a purpose-built screening form. The risk of bias in the included studies was assessed using the revised Cochrane Risk of Bias tool for randomised trials (RoB 2.0) (Sterne et al., 2019).

2.4. Data extraction

The same pairs of reviewers carried out independent data extraction of the included studies using a standardised data extraction form in Excel. This was reviewed by a third reviewer. For cases in which data was missing, or further clarification was needed, one reviewer contacted authors up to three times in one month. In addition to the original papers, further details of the unique interventions were extracted from published protocols, linked publications cited in the included papers and unpublished material that was provided by authors following a request to them).

Data was extracted on study design, population and outcomes, and an assessment of risk of bias of the included studies was carried out (See Supplementary material).

Intervention functions were coded according to descriptions provided in the BCW (Willett et al., 2019). According to this model there are nine possible functions, these include: restrictions, education, persuasion, incentivisation, coercion, training, enablement, modelling and environmental restructuring. For each intervention we identified how many and which functions were present.

BCTs were coded across the included interventions through the use of the Behaviour Change Technique (BCT) taxonomy (ver 1 (Michie et al., 2013). The BCT taxonomy v1 is a comprehensive and reliable 93-item coding framework that enables researchers to identify and code the BCTs that are included in treatment and comparator groups. Coders (LB, RB, GTT, KKM, KP) in the current study had a background in psychology/behavioural science and completed online training to apply the BCT taxonomy v1 to the included interventions. Coding was done independently and in duplicate for all studies. Any discrepancies were resolved via team discussion.

Contextual factors were extracted according to the 11 items included in the TIDieR checklist (Hoffmann et al., 2014). The checklist prompted extraction of the following information: name, rationale, core procedural and contextual elements of the intervention such as what the intervention entailed, who, how much, where and when. Plus, modifications and fidelity of the intervention. We also extracted information regarding the theories that guided the development of interventions, whenever this information was reported by the authors.

2.5. Data synthesis/analysis

2.5.1. Effective interventions and behavioural components

In line with our previous review (Peckham et al., 2023), to determine whether or not interventions were effective in increasing levels of PA, we calculated an effect size, with an effect size of >0.273 being classed as effective. Data from a systematic review to investigate the dose-response associations between accelerometry-measured physical activity and sedentary time and all-cause mortality suggests that a change of 6 min/day of MVPA is a clinically meaningful difference (Ekelund et al., 2019). The sample size calculation for the SPACES trial therefore used a target difference of 6 min/day and a standard deviation of 22 min/day. The STEPWISE RCT in patients with schizophrenia reported a standard deviation of 22 min at 12 months in the intervention arm. This is presented as a standardised effect size = 0.273 (to 3dp) (calculated by dividing 6 by 22) (Holt et al., 2019). We used the Campbell Collaboration effect size calculator to calculate Cohens D.

The decision to calculate the effect size, rather than using the information provided in the original reporting, was to ensure new studies were considered as per the previous review, which highlighted there was consistently poor reporting of results (Peckham et al., 2023). Thus, the calculated effect size provided a more consistent reference for the intervention effectiveness of all included interventions. This was

considered appropriate given the focus of this review was on intervention content as opposed to duplicating the results of our previous review.

We reported narratively on the frequency of identified intervention functions and BCTs across all the included studies and effective interventions, guided by the percentage effectiveness method outlined by Martin et al. (2013). We produced a percentage effectiveness that compared the number of effective studies that featured a particular intervention function or BCT with all studies that featured that component.

3. Results

After the removal of duplicates and the screening of titles, abstracts and full texts, the final sample consisted of 17 papers that reported on 15 unique interventions (14 contained sufficient information and were included in the analysis). Of the full texts screened 22 were excluded for being original research, 4 were not studies of people aged 18 and over, 29 were not randomised controlled trials, 23 did not have a measure of physical activity or sedentary behaviour as an outcome, 1 study did not use a validated questionnaire to measure PA and 21 were not of trials that stated an increase in PA or decrease in SB as one of the aims of the intervention. In terms of participant characteristics, 14 studies did not state that they had used ICD or DSM criteria to diagnoses SMI, in 6 studies people with SMI made up less that 70 % of the study population.

See PRISMA Flow diagram (Fig. 1).

3.1. Study characteristics

The results of data extraction of study design, population and outcomes can be found in the Supplementary materials. The trials were published between 2015 and 2023. To enable the reporting of extended follow-up periods, the outcomes of two interventions were reported across two publications, respectively (Baker et al., 2015, 2018; Jakobsen et al., 2017; Speyer et al., 2016).

The most common diagnosis that was reported across recruited participants was schizophrenia (Andersen et al., 2020; Baker et al., 2015, 2018; Bartels et al., 2015; Browne et al., 2023; Chen et al., 2017; Fernández-Abascal et al., 2023; Kaplan et al., 2018; Luciano et al., 2022; Masa-Font et al., 2015; Ryu et al., 2020; Sailer et al., 2015; Williams et al., 2019). Other diagnoses were bipolar disorder (Baker et al., 2015, 2018; Chen et al., 2017; Holt et al., 2019; Kaplan et al., 2018; Luciano et al., 2022; Masa-Font et al., 2015; Williams et al., 2019) schizoaffective disorder (Andersen et al., 2020; Bartels et al., 2015; Luciano et al., 2022; Masa-Font et al., 2015; Speyer et al., 2016; Suen et al., 2022) and major depression (Bartels et al., 2015; Luciano et al., 2022).

Eleven trials compared the intervention group with an active control group (Andersen et al., 2020; Baker et al., 2015; Bartels et al., 2015; Kaplan et al., 2018; Ryu et al., 2020; Sailer et al., 2015; Speyer et al.,

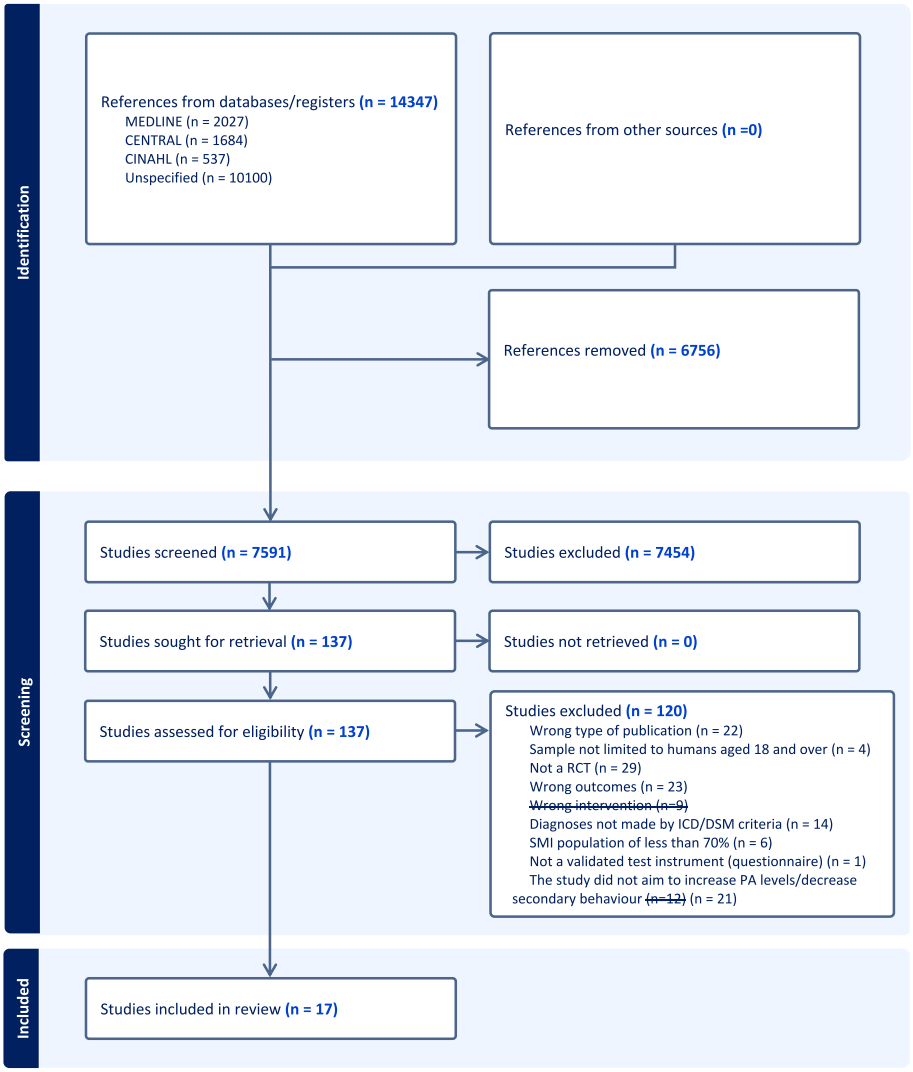

Fig. 1. PRISMA Flow Diagram.

2016) and the remaining four compared the intervention to treatment as usual (Bartels et al., 2015; Chen et al., 2017; Masa-Font et al., 2015; Williams et al., 2019).

A mixture of objective and self-reported outcome measures was used across trials. Table 1 gives details of the effect sizes for each of the included studies and the physical activity outcome that the effect size was calculated for. While all studies included PA as an outcome, only 3 included SB as an outcome (Andersen et al., 2020; Baker et al., 2015; Williams et al., 2019). As we had previously determined that none of the effect sizes for these studies were positive in favour of the intervention (Peckham et al., 2023), we did not explore this further within this review.

3.2. Risk of bias

The risk of bias for the included studies is shown in Fig. 2. Three studies were assessed as having some concerns (Fernández-Abascal et al., 2023; Kaplan et al., 2018; Luciano et al., 2022) Whilst the remaining 12 studies were assessed as being at 'high risk' of bias. The main sources of concern were potential bias due to deviations from intended intervention and the selection of the reported result. Six studies were at 'high risk' due to deviation from the intended intervention (Andersen et al., 2020; Browne et al., 2023; Chen et al., 2017; Holt et al., 2019; Ryu et al., 2020; Williams et al., 2019) and nine had 'some concerns' (Baker et al., 2015; Bartels et al., 2015; Fernández-Abascal et al., 2023; Kaplan et al., 2018; Luciano et al., 2022; Masa-Font et al., 2015; Sailer et al., 2015; Speyer et al., 2016; Suen et al., 2022). Six studies were at 'high risk' for selection of the reported results (Andersen et al., 2020; Baker et al., 2015; Bartels et al., 2015; Ryu et al., 2020; Sailer et al., 2015; Speyer et al., 2016) and six had 'some concerns (Browne et al., 2023; Chen et al., 2017; Fernández-Abascal et al., 2023; Kaplan et al., 2018; Luciano et al., 2022; Suen et al., 2022), the remaining three studies were at low risk of bias (Holt et al., 2019; Masa-Font et al., 2015; Williams et al., 2019). In measurement of the outcome six studies were at 'high risk' of bias (Baker et al., 2015; Bartels et al., 2015; Masa-Font et al., 2015; Sailer et al., 2015; Speyer et al., 2016; Suen et al., 2022) while the remaining nine studies showed 'low risk'. Four of the studies were assessed as 'high risk' for missing outcome data (Andersen et al., 2020; Browne et al., 2023; Chen et al., 2017; Ryu et al., 2020), whilst the other studies were 'low risk'. There was 'low risk' for all studies due to the randomisation process.

3.3. Intervention descriptions

A description of all the included interventions, in line with the TIDieR checklist can be found in Supporting Information 1. This provides details of the contextual features of the included interventions. Most of the interventions combined educational and practical PA components (Andersen et al., 2020; Bartels et al., 2015; Chen et al., 2017; Luciano et al., 2022; Sailer et al., 2015; Suen et al., 2022).

Many of the educational components were delivered face-to-face in a group format or individually, and provided either general education on PA or tailored advice to support individuals to become more physically active (Andersen et al., 2020; Baker et al., 2015; Bartels et al., 2015; Kaplan et al., 2018; Masa-Font et al., 2015; Ryu et al., 2020; Sailer et al., 2015; Speyer et al., 2016; Suen et al., 2022; Williams et al., 2019). One intervention provided a combination of group and individual delivery (Bartels et al., 2015), whereas one intervention provided the educational component via a written manual (Chen et al., 2017).

General education regarding PA typically covered types of PA, benefits of PA, risks of not being physically active, and how to do PA safely (Baker et al., 2015; Chen et al., 2017; Holt et al., 2019; Masa-Font et al., 2015; Williams et al., 2019). Individually tailored advice to promote PA typically aimed to target participants' motivation, develop tailored strategies to overcome barriers to participation in PA, and encourage personalised goal setting (Andersen et al., 2020; Baker et al., 2015;

Table 1
Physical activity outcomes.

Study outcome and timepoint	Intervention	Control	Effect size (95 % CI)
Andersen 2020	Mean (SD)	Mean (SD)	
MVPA mins per day 12 weeks (intervention end)	26 (Martin et al., 2013), *n = 23*	23 (Ekelund et al., 2019), *n = 25*	0.129 (−0.438–0.696)
Baker 2015	**Mean (SD)**	**Mean (SD)**	
Walking time (mins per week) 12 months[a]	353.1 (546.1), *n = 70*	209.2 (206.6), *n = 67*	0.346 (0.008–0.683)
Bartels 2015	**Mean (SD)**	**Mean (SD)**	
IPAQ vigorous MET mins 12 months (intervention end)	393.7 (1048.8)[c], *n = 52*	484.3 (1992.6)[c], *n = 52*	−0.057 (−0.441–0.328)
Browne 2023	**Mean (SD)**	**Mean (SD)**	
Steps per day 16 weeks (intervention end)	4274.429 (3039.565), *n = 14*	4503.875 (3860.307), *n = 16*	−0.066 (−0.783–0.652)
Chen 2017	**Mean (SD)**	**Mean (SD)**	
Steps per day Three months (intervention end)	9256.8 (2396.4), *n = 7*	7459.3 (2739.2), *n = 8*	0.695 (−0.350–1.739)
Fernandez-Abascal 2023	**Mean (standard error)**	**Mean (standard error)**	
Total METs (weekly) 12 weeks (intervention end)	1726.04 (312.20), *n = 24*	1795.88 (394.13), *n = 24*	−0.04 (−0.606–0.526)
Holt 2019	**Mean (SD)**	**Mean (SD)**	
MVPA (mins per day) 12 months (intervention end)	15.4 (21.7), *n = 167*	11.8 (19.3), *n = 173*	0.176 (−0.038–0.389)
Luciano 2022	**Mean (SD)**	**Mean (SD)**	
Total METs (weekly) 6 months (intervention end)	1672.80 (2487.93), *n = 206*	1370.87 (1973.90), *n = 195*	0.134 (−0.062–0.330)
Masa-Font 2015	**Mean (SD)**	**Mean (SD)**	
Total METs (weekly) 3 months (intervention end)	1532.0 (1539.6), *n = 166*	1405.4 (12431.9), *n = 160*	0.014 (−0.203–0.232)
Speyer 2016	**Mean (SD)**	**Mean (SD)**	
MVPA (hours per week) 12 months (intervention end)	2.5 (4.0), *n = 138*	2.5 (4.0), *n = 148*[d]	0 (−0.232–0.232)
Suen 2022	**Mean (SD)**	**Mean (SD)**	
Total METs (weekly) 16 weeks (intervention end)	4601.67 (4708.48), *n = 30*	2524.82 (2277.75), *n = 27*	0.552 (0.023–1.082)
Williams 2020	**Mean (standard error)**	**Mean (standard error)**	
MVPA (mins per day) 17 weeks (intervention end)	166.5 (22.9), *n = 14*	105.1 (14.6), *n = 17*	0.844 (0.106–1.582)

[a] Intervention endpoint was between the 15 week and 12 month follow-up.

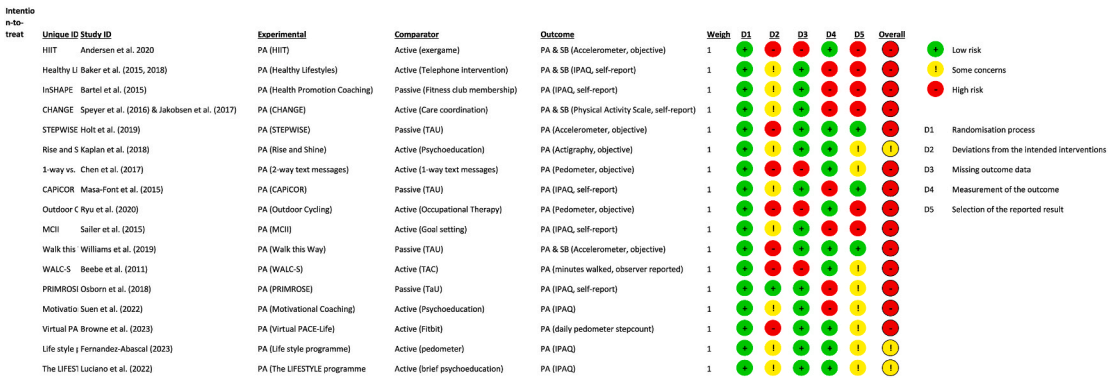

Fig. 2. Risk of bias assessment.

Bartels et al., 2015; Holt et al., 2019; Masa-Font et al., 2015; Ryu et al., 2020; Sailer et al., 2015; Speyer et al., 2016; Williams et al., 2019).

PA components took a range of formats. In most interventions, supervised group PA sessions were made available to participants. These included high-intensity interval training (Bartels et al., 2015; Browne et al., 2023), walking (Browne et al., 2023; Masa-Font et al., 2015; Williams et al., 2019) outdoor cycling (Ryu et al., 2020) and outdoor jogging (Sailer et al., 2015). Due to Covid-19 the walking intervention provided in Browne et al. (2023) was an online group intervention rather than face to face. Suen et al. (2022) and Chen et al. (2017) did not provide a supervised PA component, but increase in daily step count was a key component to be achieved by participants during the intervention in Chen et al. (2017).

Two interventions assigned each participant a trained facilitator to provide one-to-one support for the duration of the intervention. The facilitators met with participants either in their homes or at a local fitness facility to provide PA-related coaching (Bartels et al., 2015; Speyer et al., 2016).

The four interventions that were considered effective were Baker et al. (2015, 2018), Chen et al. (2017), Williams et al. (2019) and Suen et al. (2022). See Table 1. These outcomes were based on walking time (Baker et al., 2015, 2018), steps per day (Chen et al., 2017), total METs (Suen et al., 2022) and MVPA (Williams et al., 2019). Apart from Baker which used the IPAQ, all outcomes were objectively measured using a pedometer (Chen et al., 2017) or an accelerometer (Suen et al., 2022; Williams et al., 2019).

3.4. Intervention functions

Seven intervention functions were identified in at least one of the 14 included interventions (see Table 2). Interventions defined as effective were those that had an effect size of >0.273. Those most frequently reported were *education* and *environmental restructuring* (n = 14 interventions each), both of which were identified in all four effective interventions (Baker et al., 2015, 2018; Chen et al., 2017; Suen et al., 2022; Williams et al., 2019). Other frequently included functions were *enablement* (n = 13) and *persuasion* (n = 9). Only one function had a 100 % effectiveness ratio; *incentivisation* (Baker et al., 2015). However, this function was only reported in one effective intervention. The *persuasion* function had the second highest effectiveness ratio at 33 %.

3.5. BCTs

Twenty-four BCTs were used in at least one of the 14 included interventions (Kaplan not included). The total number of BCTs reported in each included study intervention ranged from 5 BCTs to 14 (see Supporting Information 1). BCTs *adding objects to the environment* (n = 13) (such as pedometers, manuals), *behavioural practice/rehearsal* (n = 10), and *instructions on how to perform the behaviour* (n = 8) were the most frequently used (see Table 3).

Only one BCT achieved a 100 % effectiveness ratio (present in only effective studies): *framing/reframing* (n = 1). Baker and colleagues' (Baker et al., 2015, 2018) intervention was the only one to include *framing/reframing*. This was employed via the suggestion to adopt a new perspective on health behaviours through use of motivational interviewing and cognitive behavioural therapy.

Feedback on behaviour (66 %), and *self-monitoring* (57 %) had the next highest effectiveness ratios. *Feedback on behaviour* was present in two effective interventions and was either delivered remotely via a bespoke health promotion website (Chen et al., 2017) or face-to-face during a one-to-one appointment with the intervention facilitator (Baker et al., 2015, 2018). *Self-monitoring of behaviour* was present in all four effective studies. In Chen, Williams and Baker (Baker et al., 2015, 2018; Chen et al., 2017; Williams et al., 2019) this was done daily by recording pedometer data and in Suen et al. (2022), participants self-monitored longer term exercise plans based on levels of motivation. Similarly, *adding objects to the environment* (such as pedometers or manuals) was also present in all four effective interventions (Baker et al., 2015, 2018; Chen et al., 2017; Suen et al., 2022; Williams et al., 2019), but also in most of the ineffective interventions (Andersen et al., 2020; Bartels

Table 2
Intervention functions, comparing effective and non-effective interventions.

Intervention functions	Effective interventions (n = 4)	Not effective interventions (n = 10)	All interventions (n = 14[a])	Effectiveness ratio
Education	4	10	14	29 %
Persuasion	3	6	9	33 %
Incentivisation	1	0	1	100 %
Coercion	0	0	0	0 %
Training	1	7	8	13 %
Enablement	3	10	13	23 %
Modelling	1	3	4	25 %
Environmental restructuring	4	10	14	29 %
Restrictions	0	0	0	0 %

[a] Kaplan et al., 2018 not included in line with the previous review; this intervention showed too much incongruence with the other included interventions due to its primary aim, which was to decrease levels of subjective sleep inertia.

Table 3
Behaviour change techniques, comparing effective and not effective interventions.

BCTs present in one or more intervention	Effective interventions (n = 4)	Not effective interventions (n = 10)	All interventions (n = 14)	Effectiveness ratio
1.1 Goal setting (behaviour)	2	5	7	29 %
1.2 Problem solving	2	4	6	33 %
1.3 Goal setting (outcome)	0	2	2	0 %
1.4 Action planning	2	5	7	29 %
1.5 Review behaviour goal(s)	2	2	5	40 %
2.1 Monitoring of behaviour by others without feedback	0	4	4	0 %
2.2 Feedback on behaviour	2	1	3	66 %
2.3 Self-monitoring of behaviour	4	3	7	57 %
2.6 Biofeedback	0	2	2	0 %
3.1 Social support (unspecified)	0	5	5	0 %
3.2 Social support (practical)	1	4	5	20 %
3.3 Social support (emotional)	3	4	7	43 %
4.1 Instruction on how to perform the behaviour	3	5	8	38 %
5.1 Information about health consequences	3	4	7	43 %
6.1 Demonstration of behaviour	0	1	1	0 %
7.1 Prompts/cues	1	1	2	50 %
8.1 Behavioural practice/rehearsal	2	8	10	20 %
8.7 Graded tasks	1	2	3	33 %
9.1 Credible source	1	3		33 %
9.2 Pros and cons	0	1	1	0 %
10.1 Material incentive (behaviour)	0	1	1	0 %
12.5 Adding objects to the environment	4	9	13	31 %
12.6 Body changes	0	1	1	0 %
13.2 Framing/reframing	1	0	1	100 %

*Kaplan et al., 2018 not included.

et al., 2015; Browne et al., 2023; Fernández-Abascal et al., 2023; Luciano et al., 2022; Masa-Font et al., 2015; Ryu et al., 2020; Sailer et al., 2015; Speyer et al., 2016), so whilst frequently used and seemingly effective, this BCT only achieved an effectiveness ratio of 31 %.

3.6. Contextual features

No contextual features were identified as unique to the effective interventions, with the exception of one effective intervention (Suen, 2022) (Suen et al., 2022), which only included female participants. Support was offered in all effective interventions, with three studies (Baker et al., 2015, 2018; Chen et al., 2017; Williams et al., 2019) offering this on an individual basis throughout the interventions, and one study (Suen et al., 2022) offering group-based only support throughout the intervention. All effective interventions were delivered either in community mental health settings or with options regarding the setting (Chen et al., 2017) and were delivered by non-physical activity specialists, but professionals with a therapeutic background with training in delivering the intervention. Three effective studies (Baker et al., 2015, 2018; Chen et al., 2017; Williams et al., 2019) provided participants with pedometers as a means to track their daily activity levels, and all included an educational component (Baker et al., 2015, 2018; Chen et al., 2017; Suen et al., 2022; Williams et al., 2019). These contextual features taken individually were not unique to the effective interventions, but their combination seemed to be for 3 of the 4 effective interventions.

3.7. Theories which guided the development of interventions

Ten studies explicitly stated the theoretical underpinnings that had been used to develop PA interventions (see Supporting Information 1). Five interventions had been based on a single theory (Andersen et al., 2020; Browne et al., 2023; Chen et al., 2017; Ryu et al., 2020; Williams et al., 2019). These were Social Cognitive Theory (Andersen et al., 2020), Transtheoretical Stages of Change Model (Chen et al., 2017), Self-Determination Theory (Browne et al., 2023; Ryu et al., 2020) and the Capability, Opportunity and Motivation Model of Behaviour Change (Williams et al., 2019). Five interventions had been based on a combination of theories (Baker et al., 2015; Browne et al., 2023; Holt et al., 2019; Luciano et al., 2022; Sailer et al., 2015; Speyer et al., 2016). These were Motivational Interviewing and Cognitive Behavioural Therapy (Baker et al., 2015; Luciano et al., 2022), Self-regulation Theory, Self-efficacy and Relapse Prevention Model (Holt et al., 2019), the Transtheoretical Stages of Change Model, Motivational Interviewing and an Assertive approach (Speyer et al., 2016); and, Mental Contrasting and Implementation Intentions (Sailer et al., 2015). These are all commonly used theories in health behaviour change, but no underpinning theory was more commonly used across the interventions or in the effective interventions compared to those which were not effective. Interventions described by Bartels (Bartels et al., 2015), Masa-Font (Masa-Font et al., 2015), Suen (Suen et al., 2022) and Fernandez-Abascal (Fernández-Abascal et al., 2023) did not provide details of the theoretical approach.

4. Discussion

This systematic review develops emerging literature on interventions aiming to increase PA in people with SMI by identifying the key approaches, components and contextual features that have been employed in the interventions to date. Seventeen papers that report 15 unique interventions were identified, four of which were considered effective. However, overall the evidence base at this time is limited, with 12 of the included studies at overall high risk of bias. While this review is the first to systematically describe the intervention content of PA interventions for people with SMI, small sample sizes and poor reporting of the included interventions restrict our ability to draw firm conclusions about the best way(s) to support PA in this population.

The most common approaches to encouraging PA in this population involved providing instruction and the opportunity to practice how to perform physical activity alongside the use of pedometers to track behaviour. Effective interventions were mostly delivered by community mental health teams and professionals not from a physical activity background. Most were delivered face-to-face in a group setting, with the opportunity for one-to-one support.

4.1. Intervention functions

The most common functions of the included interventions were to improve education around PA and environmental restructuring. While both functions were present in all four effective studies, they also

featured in some non-effective studies, therefore we cannot draw firm conclusions about their contribution to effectiveness. The only function that achieved a 100 % effectiveness was incentivisation, but this was based on its inclusion in just one of the effective interventions. The incentives in Baker et al. (2015, 2018) were financial/material in nature and aimed to target motivation. Targeted incentives delivered in line with evidence-based behaviour change frameworks such as COM-B (targeting capability, opportunity, or motivation) have been shown to improve compliance across other health behaviours, however there are concerns about the sustainability of providing incentives long-term as they may be unreliable over time and are associated with over-reliance on extrinsic motivation (Vlaev et al., 2019). Previous reviews have decided to exclude functions and/or BCTs that appear in a single study only (Martin et al., 2013). As the number of effective interventions in our review was small, we decided to include these components, but their potential effectiveness must be interpreted with caution. Training and modelling were the only functions that were used solely by ineffective interventions, and neither coercion nor restriction have been trialled to date. Coercion has been used as a function within the inpatient setting for adults with SMI (Tetlie et al., 2009), but may be less appropriate in the out-patient setting.

4.2. BCTs

We also sought to identify potentially useful BCTs in the published studies. As with intervention functions, the most common BCT, adding objects to the environment, was present in all four effective interventions, but also reported in several of the ineffective interventions. In most studies this included PA sessions, a wearable device and/or a manual. Chen et al. (2017) also provided text messages. Three BCTs achieved above 50 % effectiveness meaning they appeared in more effective studies than ineffective. These were framing/reframing, self-monitoring and feedback on behaviour. Only one BCT achieved 100 % effectiveness (framing/reframing) and again this was only present in the Baker study (Baker et al., 2015, 2018). Baker et al. describe using a combination of CBT and MI which focus on identifying and changing negative and unhelpful thinking patterns, although specific details of how this was done in relation to physical activity is not reported. Self-monitoring was done using pedometers in all but the study by Suen (Suen et al., 2022) in combination with daily monitoring forms in Baker and Williams (Baker et al., 2015, 2018; Williams et al., 2019). Monitoring and particularly self-monitoring, is one of the most studied behaviour change techniques. It has been shown to be effective in changing a range of behaviours through promoting awareness and engagement (Compernolle et al., 2019; Noser et al., 2022). Feedback on behaviour has also shown to be effective when combined with other strategies such as goal setting and self-monitoring (Soltani et al., 2016; Van Rhoon et al., 2020). Taken together, these four BCTs (adding objects to the environment, framing/reframing, self-monitoring and feedback on behaviour) could provide a useful starting point in the design of future interventions, particularly as together they target all three of the key determinants of behaviour (capability, opportunity and motivation) (Michie et al., 2011). However, the inclusion of techniques that seem less effective than others based on the limited evidence currently available should not be ruled out especially given interventions with a higher overall number of BCTs appeared to be more effective. Furthermore, our previous research suggests that motivation can be a particular challenge for this population (Tew et al., 2023), and a study exploring associations between PA, SB and motivation in people with SMI across four countries also highlighted that this is a universally relevant determinant of these behaviours, with autonomous motivation being particularly important (Chapman et al., 2024). Therefore consideration of BCTs that specifically address motivation (for example goal setting, pros and cons, self-talk and positive reinforcement) may be additionally useful for people with SMI (Carey et al., 2019).

4.2.1. Contextual factors

Consideration of the context of the intervention is crucial to the potential success of interventions. The TIDieR checklist (Hoffmann et al., 2014) was used to identify contextual features of published interventions that may be an important consideration during the development of future programmes in this area. Common contextual features, irrespective of effectiveness were the inclusion of an educational component, opportunity to practice and the use of a tool to track PA behaviour such as a pedometer. These are common features of interventions that are designed to encourage increases in levels of PA and are not necessarily specific to this population (Greaves et al., 2011). The majority of the interventions were delivered via community mental health teams. This may be a useful approach, but a recent study has also suggested the need to consider participant preferences for support from other sources (Tew et al., 2023). Service delivery teams must be involved in a way that facilitates the goal but does not reinforce hierarchical models of care. Although evidence for the effectiveness of individual features was weak, a combination of multiple features could be the key to the creation of an effective intervention (e.g., PA tracking and educational components).

The included studies were based on different theories to inform the development of interventions, but there was not a common theory used across the three effective interventions. Although behaviour change theory may be an important consideration for intervention developers, our previous work has also highlighted the importance of the wider context (macro-level structures) in the formation of PA behaviour (micro-level change) (Tew et al., 2023). For example, an individual with SMI who is motivated to initiate PA may live in a cultural environment (macro-level structure), where some activities are not accessible nor seen as culturally appropriate. None of the reviewed studies attempted to evaluate the effect of the wider environment on individuals' ability to increase their PA levels.

In this review we did not consider factors such as intervention environments, providers and participant characteristics as this was beyond the scope of this review, however we recommend that these factors should be explored in future research.

4.3. Strengths and limitations

The strengths of this review included the rigorous data extraction, coding and consensus procedures. The review only included RCTs and used effect sizes and effectiveness ratios to examine the evidence for both effective and ineffective interventions in this area. Within the review, we report interventions in comprehensive detail through the application of the standardised TIDieR checklist (Hoffmann et al., 2014). This enables the replication of successful results and adaptation to other behaviours/populations. The review is one of the first to attempt to unpack the content of effective interventions, by identifying the potentially useful intervention functions, techniques and contextual features that were found in effective interventions compared to ineffective interventions.

There are several limitations to this review. Firstly, the possible choice of methods of analysis were restricted due to poor reporting of outcomes in the included papers. Data was not sufficient to perform meta-analyses and similarly we were unable to calculate promise ratios as has been achieved in previous reviews (e.g. Gardner et al., 2016) as this would require the reporting of both within and between group outcomes, which, in the included papers, were typically either omitted or unreliable. Only 3 of the identified studies examined the impact of the intervention on SB, and none of these were effective. We therefore did not explore the content of these interventions further in the context of SB. There is on-going debate around how sedentary behaviour should be measured which may partially account for why more studies have not explored it as an outcome to date (Prince et al., 2020). Furthermore, due to the poor reporting and lack of information, 12 of the included studies are at high risk of bias which means that results should be interpreted

with caution. This highlights the overall poor quality of research in this area to date as highlighted by both our previous review (Peckham et al., 2023), and another review which focused on PA interventions that included both PA and psychosocial strategies in people living with SMI (Naylor et al., 2024). The latter found limited evidence of effectiveness of these interventions and highlighted significant methodological limitations in this area of research (59). Taken together the findings from these reviews identify a clear need for well-designed, clearly reported and adequately powered RCTs to explore the effectiveness of clearly described interventions to increase PA in this population.

In addition, the chosen method of analysis also does not allow the exploration of possible interactions between combinations of intervention functions, BCTs and contextual factors. As the included studies did not systematically vary or isolate individual BCTs, it is difficult to disentangle their independent and combined effects, and makes robust analysis of BCT interactions challenging. Future research, such as factorial trials or qualitative Comparative Analysis (QCA) (Schneider & Wagemann, 2012) could support the investigation of synergistic or antagonistic interactions between techniques as the data in this area develops. In some of the current papers, intervention functions and BCTs were either poorly reported or absent, which may have impacted our ability to code and thus draw conclusions across a modest number of studies. Due to the overall poor reporting of studies, we recommend that future studies utilise reporting tools such as the TIDieR framework as a method to report interventions. Poor reporting has been identified as a major limitation of previous reviews of BCTs (Soltani et al., 2016). We note that as a result of frameworks such as TIDieR, reporting of intervention components appears to have improved over time, with more recent studies (particularly Browne and Fernandez (Browne et al., 2023; Fernández-Abascal et al., 2023) documenting higher numbers of BCTs which may have affected the results. This better reporting would provide future research with a clearer picture than has been provided thus far of effective intervention functions, BCTs and contextual features for PA intervention development for people with SMI. Future studies should report not only the theories on which interventions are based, but also explain the mechanisms through which the interventions are hypothesised to work. Additionally, with the recent development of the behaviour change technique ontology (Marques et al., 2024), future studies may wish to consider utilising this approach to synthesise 'what works' within PA interventions for people with SMI.

5. Conclusions

This systematic review maps the emerging literature on PA interventions for people with SMI by identifying the key approaches and components that have been employed in the interventions trialled to date. We identified intervention features that were unique to effective interventions, but future interventions should not rule out the use of components that were seen in 'non-effective' studies, given the limited evidence base, poor reporting, high risk of bias, and possibility of effects from the combination and/or interaction between BCTs that we were not able to explore.

Together with the authors' previous review, the current review suggests that future studies should focus on clear reporting of intervention content and well-designed evaluation studies to improve our understanding of the intervention components (or combinations) that are most effective for increasing PA in people with SMI.

CRediT authorship contribution statement

Gemma Traviss-Turner: Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Rebecca J. Beeken:** Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Gareth Jones:** Writing – original draft, Methodology, Formal analysis. **Laura Bailey:** Writing – original draft, Methodology, Formal analysis. **Eleanor Bowes:** Writing – review & editing. **Trys Burke:** Writing – review & editing. **Katarzyna K. Machaczek:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Katie Pickering:** Writing – review & editing, Methodology, Formal analysis. **Robert Copeland:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Cindy Cooper:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Garry Tew:** Writing – review & editing, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Scott Weich:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Emily Peckham:** Writing – review & editing, Methodology, Funding acquisition, Formal analysis, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mhpa.2025.100713.

Data availability

The authors do not have permission to share data.

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