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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Title: 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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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**

2 People who live with severe mental ill health (SMI), including schizophrenia and bipolar disorder, die

3 on average 10-20 years earlier than those without SMI (1). The majority of these deaths are

4 attributed to preventable physical health conditions such as cardiovascular disease and type 2

5 diabetes (2,3). In the wider population, there is robust evidence that higher physical activity (PA)

6 behaviour and lower levels of sedentary behaviour (SB; defined as any waking behaviour expending

7 energy at a rate ≤1.5 metabolic equivalents while in a sitting, reclining or lying posture (4)) can

8 reduce the incidence of these diseases (5). There is also a growing body of evidence to suggest

9 increasing levels of PA among people with SMI can also reduce the risks of these conditions,

10 alongside other benefits such as reductions in the severity of depressive and schizophrenic

11 symptoms, , and improved quality of life (6–9). However, a global meta-analysis found that people

12 with SMI engage in 38.4 min of moderate to vigorous activity (MVPA) per day, compared with 47.6

13 min per day in individuals without SMI. Furthermore, they are less likely to meet UK Government

14 guidelines of 150 min MVPA per week (7). They also experience unique barriers that prevent them

15 from engaging in PA, such as increased mental health symptoms, lack of social support, the side

16 effects of medication, tiredness and reduced motivation (10).

17 Behavioural interventions are required that promote regular PA among this group. Whilst there is a

18 profusion of studies of complex interventions in this space, there is little evidence of effectiveness, in

19 part because research to date has been of low quality due to small sample size and poor quality of

20 reporting. A 2018 review of the outcomes of controlled and uncontrolled trials that were designed

21 to increase levels of PA in people with SMI found low-quality evidence of a benefit in 7/16 controlled

22 studies and no improvement in 3/16 controlled studies (11). A more recent systematic review

23 performed by the authors of this paper identified 11 unique randomised controlled trials (RCTs) of

24 interventions, of which three were deemed to have been effective at increasing levels of PA (an

25 effect size of >0.273 was classed as effective) (12).

26   Previous reviews have not examined the content or contextual features of identified interventions in

27   sufficient detail. To better understand which elements of intervention *content* contribute to

28   intervention effectiveness, a theory-informed approach is beneficial. Such approaches can elucidate

29   the mechanisms through which interventions operate, identifying theoretical constructs that are

30   consistently associated with positive outcomes. This can support the design of future interventions

31   that are both evidence-based and theoretically coherent.

32   The behaviour change wheel (BCW) provides a comprehensive framework for analysing and

33   developing behaviour change interventions (18). It is grounded in the COM-B model, which proposes

34   that behaviour (B) results from the interaction of three key components: capability (the individual's

35   physical and psychological ability to perform the behaviour), opportunity (the physical and social

36   environment that enables the behaviour), and motivation (the reflective and automatic processes

37   that drive behaviour). According to this model, effective interventions must address one or more of

38   these components to bring about behaviour change. Surrounding the COM-B system are nine

39   intervention functions (e.g., education, persuasion, training, enablement), which represent broad

40   strategies that can be used to influence the COM-B components. These intervention functions

41   provide a practical bridge between theoretical understanding and real-world intervention design

42   A novel review focused on describing the content of interventions aimed at improving PA and/or

43   decreasing SB in SMI ,including coding them based on BCW intervention function, could help to

44   identify more clearly the broad approaches that could effectively promote PA within this population

45   (14).

46   The functions within the BCW can also be broken down into more specific behaviour change

47   techniques (BCTs). For example, the intervention function 'education' incudes BCTs such as

48   'information about health consequences' and 'information about antecedents'. The Behaviour

49   Change Technique (BCT) taxonomy (15) is a structured taxonomy of behaviour change techniques

50   that was developed to provide a method for specifying intervention content. It has been used

51 extensively in systematic reviews in other areas to identify reliably those BCTs that were associated

52 with promising behavioural interventions. For example, previous systematic reviews of PA

53 interventions have suggested that the number of BCTs and use of techniques such as self-monitoring

54 and goal setting are associated with improved outcomes (16–18). However, the effectiveness of

55 specific techniques may vary according to the population being targeted (or context), and the

56 techniques in PA interventions for people with SMI have not been evaluated.

57 Previous reviews of behaviour change interventions have taken one of three approaches to evaluate

58 the potential usefulness of different intervention functions and BCTs (19). These include meta-

59 regression, or in cases in which meta-analysis is not possible, the calculation of a promise ratio or

60 /percentage effectiveness. A promise ratio calculates the frequency of use of a specific component

61 or technique in 'very' or 'quite' promising studies compared with its use in 'not' promising studies

62 (14). Studies are categorised as very promising if a significant difference is observed (on the outcome

63 of interest) both within a group and between comparator groups, whereas studies that demonstrate

64 a difference only within a group or between groups are categorised as quite promising (14). The

65 percentage effectiveness method, on the other hand, is a simple comparison of the number of

66 effective studies that feature a particular component or technique with all of the studies that

67 feature that technique (20). The latter approach may be useful in cases where an existing review has

68 already classified an intervention as effective and where this classification differs from the original

69 manuscripts (e.g. based on effects sizes using data provided by authors as was done in our recent

70 review (12)).

71 Identifying both the broader intervention functions and the BCTs that are used within existing

72 interventions, alongside their contextual features, could help to inform future interventions that

73 would help people with SMI to increase their levels of PA and/or reduce their SB to ultimately

74 improve their health outcomes.

75   This review aimed to build on, and complement, our earlier review of intervention effectiveness (12)

76   through using the Behaviour Change Wheel, BCT taxonomy (v1) and template for intervention

77   description and replication (TIDieR) checklist (21) to identify the intervention functions, BCTs and

78   contextual features (including underpinning theories) that have been used to increase PA and/or

79   decrease SB in people with SMI within published intervention literature. In doing so, this review

80   addresses a critical evidence gap by providing a structured and theory-informed synthesis of how PA

81   and SB interventions for people with SMI have been designed and reported, which is essential for

82   informing future intervention development and replication.

83   **Methods**

84   The review included an updated search of the literature included in the previously published review

85   focused on the effectiveness of interventions to increase PA or decrease SB in people with SMI (12),

86   to ensure the inclusion of any new, relevant studies given the time elapsed. However, the focus of

87   this review is on intervention content and not effectiveness, as this was explored in the prior review.

88   The protocol for this update was prospectively registered on the PROSPERO register of systematic

89   reviews: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=541859. The review

90   has been reported according to the Preferred Reporting Items for Systematic Reviews and Meta-

91   analysis (PRISMA) 2021 statement (22). The search strategy, eligibility criteria and study selection

92   methods were aligned to those used in the previous review (with an extended date for the search)

93   but are also included here for completeness.

94   *Search strategy*

95   An electronic search strategy that combined search terms for SMI, PA, SB and RCTs was used to

96   search the following databases from their respective inception dates to June 2024: MEDLINE

97   (PubMed), EMBASE, PsycINFO, NIHR Library, CENTRAL and CINAHL (see (12) for full strategy).

98   Backward citation searching was conducted by inspecting reference lists of identified eligible studies.

4

99   *Eligibility criteria*

100   Eligibility criteria are reported in line with the Population, Intervention, Comparison, Outcome and

101   Study (PICOS) framework (23).

102   Type of participant/population:

103   Participants were aged 18 or above and diagnosed with a SMI, which was defined in this review as

104   schizophrenia or other psychotic disorders, bipolar disorder or depression with psychotic features.

105   This classification is based on those that would appear on a UK Primary Care SMI database (24). The

106   diagnosis must have been made using the International Classification of Diseases (ICD) or Diagnostic

107   and Statistical Manual (DSM) criteria. Studies that failed to specify this were excluded. Studies that

108   included participants with SMI and other diagnoses were eligible if the reporting of the results

109   enabled the extraction of data for participants with SMI, or if more than 70% of participants had

110   SMI, as indicated by descriptive statistics.

111   Type of interventions:

112   Interventions that were designed to increase time spent in any form of PA or to reduce time spent in

113   SB were included, with no limits on the duration, setting or content of the intervention.

114   Multi-component or multi-behavioural interventions (e.g., dietary modification or smoking

115   cessation) were included only where change in PA or SB was one of the described intervention

116   objectives.

117   Type of comparison:

118   Passive control conditions were included; these might be treatment as usual, waiting list control or

119   no treatment conditions. Active conditions were also included, such as alternative cognitive or

120   behavioural approaches. Studies that failed to report a control condition or where two (or more)

121   interventions were compared with neither described as a 'control', were not eligible for inclusion in

122   this review.

5

123   Type of outcome measures:

124   Studies that reported validated outcome measures of PA and/or SB were included. Eligible outcomes

125   took the form of data that were collected either using devices (e.g. pedometers, accelerometers, or

126   inclinometers) or questionnaires (i.e., self-reported data).

127   Types of studies:

128   The studies were RCTs that were published in English and that targeted change in levels of PA or SB

129   among people with SMI as one of the intervention objectives. Studies were eligible if they had been

130   conducted in either in-patient or community settings.

131   *Study selection*

132   Two authors (EP and RB) performed the searches and all results were imported to Covidence

133   (https://www.covidence.org/), a web-based screening and data extraction tool that is designed to

134   assist the management of systematic reviews. Covidence was used to remove duplicates and screen

135   the titles, abstracts and full texts of the articles.

136   Pairs of reviewers screened all titles and abstracts independently for relevance to the inclusion

137   criteria (GTT, RB, GJ, LB, EB, TB, KM, KP, EP). Discrepancies were resolved by discussion and third-

138   party arbitration. The same approach was used to screen the full texts that had been identified as

139   potentially relevant according to a purpose-built screening form. The risk of bias in the included

140   studies was assessed using the revised Cochrane Risk of Bias tool for randomised trials (RoB 2.0)

141   (25).

142   *Data extraction*

143   The same pairs of reviewers carried out independent data extraction of the included studies using a

144   standardised data extraction form in Excel. This was reviewed by a third reviewer. For cases in which

145   data was missing, or further clarification was needed, one reviewer contacted authors up to three

146   times in one month. In addition to the original papers, further details of the unique interventions

6

147   were extracted from published protocols, linked publications cited in the included papers and

148   unpublished material that was provided by authors following a request to them).

149   Data was extracted on study design, population and outcomes, and an assessment of risk of bias of

150   the included studies was carried out (See Supplementary material).

151   Intervention functions were coded according to descriptions provided in the BCW (18). According to

152   this model there are nine possible functions, these include: restrictions, education, persuasion,

153   incentivisation, coercion, training, enablement, modelling and environmental restructuring. For each

154   intervention we identified how many and which functions were present.

155   BCTs were coded across the included interventions through the use of the Behaviour Change

156   Technique (BCT) taxonomy (ver1 (15). The BCT taxonomy v1 is a comprehensive and reliable 93-item

157   coding framework that enables researchers to identify and code the BCTs that are included in

158   treatment and comparator groups. Coders (LB, RB, GTT, KKM, KP) in the current study had a

159   background in psychology/behavioural science and completed online training to apply the BCT

160   taxonomy v1 to the included interventions. Coding was done independently and in duplicate for all

161   studies. Any discrepancies were resolved via team discussion.

162

163   Contextual factors were extracted according to the 11 items included in the TIDieR checklist (21).

164   The checklist prompted extraction of the following information: name, rationale, core procedural

165   and contextual elements of the intervention such as what the intervention entailed, who, how

166   much, where and when. Plus, modifications and fidelity of the intervention. We also extracted

167   information regarding the theories that guided the development of interventions, whenever this

168   information was reported by the authors.

169   *Data synthesis/analysis*

170   Effective interventions and behavioural components

171   In line with our previous review (12), to determine whether or not interventions were effective in

172   increasing levels of PA, we calculated an effect size, with an effect size of >0.273 being classed as

173   effective. Data from a systematic review to investigate the dose-response associations between

174   accelerometry-measured physical activity and sedentary time and all-cause mortality suggests that a

175   change of 6 min/day of MVPA is a clinically meaningful difference (26). The sample size calculation

176   for the SPACES trial therefore used a target difference of 6 min/day and a standard deviation of 22

177   min/day. The STEPWISE RCT in patients with schizophrenia reported a standard deviation of 22

178   minutes at 12 months in the intervention arm. This is presented as a standardised effect size = 0.273

179   (to 3dp) (calculated by dividing 6 by 22) (27). We used the Campbell Collaboration effect size

180   calculator to calculate Cohens D.

181   The decision to calculate the effect size, rather than using the information provided in the original

182   reporting, was to ensure new studies were considered as per the previous review, which highlighted

183   there was consistently poor reporting of results (12). Thus, the calculated effect size provided a

184   more consistent reference for the intervention effectiveness of all included interventions. This was

185   considered appropriate given the focus of this review was on intervention content as opposed to

186   duplicating the results of our previous review.

187   We reported narratively on the frequency of identified intervention functions and BCTs across all the

188   included studies and effective interventions, guided by the percentage effectiveness method

189   outlined by (20). We produced a percentage effectiveness that compared the number of effective

190   studies that featured a particular intervention function or BCT with all studies that featured that

191   component.

192

193   **Results**

194   After the removal of duplicates and the screening of titles, abstracts and full texts, the final sample

195   consisted of 17 papers that reported on 15 unique interventions (14 contained sufficient

196   information and were included in the analysis). Of the full texts screened 22 were excluded for

197   being original research, 4 were not studies of people aged 18 and over, 29 were not randomised

198   controlled trials, 23 did not have a measure of physical activity or sedentary behaviour as an

199   outcome, 1 study did not use a validated questionnaire to measure PA and 21 were not of trials that

200   stated an increase in PA or decrease in SB as one of the aims of the intervention. In terms of

201   participant characteristics, 14 studies did not state that they had used ICD or DSM criteria to

202   diagnoses SMI, in 6 studies people with SMI made up less that 70% of the study population.

203
204   See PRISMA Flow diagram (Figure 1).

205   *Study Characteristics*

206   The results of data extraction of study design, population and outcomes can be found in the

207   Supplementary materials. The trials were published between 2015 and 2023. To enable the

208   reporting of extended follow-up periods, the outcomes of two interventions were reported across

209   two publications, respectively (28–31).

210   The most common diagnosis that was reported across recruited participants was schizophrenia

211   (28,29,32–42). Other diagnoses were bipolar disorder (27,28,29,,34,35,37,40,42) schizoaffective

212   disorder (31–33,37,40,43) and major depression (33,40)

213   Eleven trials compared the intervention group with an active control group (28,31–33,36,38,42) and

214   the remaining four compared the intervention to treatment as usual (33–35,37).

215   A mixture of objective and self-reported outcome measures was used across trials. Table 1 gives

216   details of the effect sizes for each of the included studies and the physical activity outcome that the

217   effect size was calculated for. While all studies included PA as an outcome, only 3 included SB as an

9

218   outcome (28,32,35). As we had previously determined that none of the effect sizes for these studies

219   were positive in favour of the intervention (12), we did not explore this further within this review.

220   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 (20), *n=23*	23 (26), *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			

221

222   Risk of Bias

223   The risk of bias for the included studies is shown in Figure 2. Three studies were assessed as having

224   some concerns (39,40,42) Whilst the remaining 12 studies were assessed as being at 'high risk' of

225   bias. The main sources of concern were potential bias due to deviations from intended intervention

226   and the selection of the reported result. Six studies were at 'high risk' due to deviation from the

227   intended intervention (27,32,34-36,41) and nine had 'some concerns' (28,31,33,37-40,42,43,). Six

228   studies were at 'high risk' for selection of the reported results (28,31–33,36,38) and six had 'some

229   concerns (34,39,40-43), the remaining three studies were at low risk of bias (27,35,37,). In

230   measurement of the outcome six studies were at 'high risk' of bias (28,31,33,37,38,43) while the

231   remaining nine studies showed 'low risk'. Four of the studies were assessed as 'high risk' for missing

232   outcome data (32,34,36,41), whilst the other studies were 'low risk'. There was 'low risk' for all

233   studies due to the randomisation process.

234   *Intervention descriptions*

235   A description of all the included interventions, in line with the TIDieR checklist can be found in

236   Supporting Information 1. This provides details of the contextual features of the included

237   interventions. Most of the interventions combined educational and practical PA components

238   (32,33,34–38-40,43).

239   Many of the educational components were delivered face-to-face in a group format or individually,

240   and provided either general education on PA or tailored advice to support individuals to become

241   more physically active (28,31–33,35–38-40,42,43). One intervention provided a combination of

11

242 group and individual delivery (33), whereas one intervention provided the educational component

243 via a written manual (34).

244 General education regarding PA typically covered types of PA, benefits of PA, risks of not being

245 physically active, and how to do PA safely (27,28,34,35,37). Individually tailored advice to promote

246 PA typically aimed to target participants' motivation, develop tailored strategies to overcome

247 barriers to participation in PA, and encourage personalised goal setting (27,28,31-33,35–38).

248 PA components took a range of formats. In most interventions, supervised group PA sessions were

249 made available to participants. These included high-intensity interval training (33,41), walking

250 (35,37,41) outdoor cycling (36) and outdoor jogging (38). Due to Covid-19 the walking intervention

251 provided in Browne 2023 et al (41) was an online group intervention rather than face to face. Suen

252 et al (43) and Chen et al. (34) did not provide a supervised PA component, but increase in daily step

253 count was a key component to be achieved by participants during the intervention in Chen et al (34).

254 Two interventions assigned each participant a trained facilitator to provide one-to-one support for

255 the duration of the intervention. The facilitators met with participants either in their homes or at a

256 local fitness facility to provide PA-related coaching (31,33)

257 The four interventions that were considered effective were Baker et al. (2015, 2018) (28,29), Chen et

258 al. (2017) (34), Williams et al. (2019) (35) and Suen (43). See Table 1. These outcomes were based on

259 walking time (28, 29), steps per day (34), total METs (43) and MVPA (35). Apart from Baker which

260 used the IPAQ, all outcomes were objectively measured using a pedometer (34) or an

261 accelerometer(35,43).

262 *Intervention functions*

263 Seven intervention functions were identified in at least one of the 14 included interventions (see

264 Table 2). Interventions defined as effective were those that had an effect size of >0.273. Those most

265 frequently reported were *education* and *environmental restructuring* (n = 14 interventions each),

12

266   both of which were identified in all four effective interventions (28,29,34,35,43). Other frequently

267   included functions were *enablement* (n = 13) and *persuasion* (n = 9). Only one function had a 100%

268   effectiveness ratio; *incentivisation* (28). However, this function was only reported in one effective

269   intervention. The *persuasion* function had the second highest effectiveness ratio at 33%.

270   **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*)	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%

271   *Kaplan et al., 2018 not included in line with the previous review; this intervention showed too

272   much incongruence with the other included interventions due to its primary aim, which was to

273   decrease levels of subjective sleep inertia.

274

275   *BCTs*

13

276   Twenty-four BCTs were used in at least one of the 14 included interventions (Kaplan not included).

277   The total number of BCTs reported in each included study intervention ranged from 5 BCTs to 14

278   (see Supporting Information 1). BCTs *adding objects to the environment* (n = 13) (such as

279   pedometers, manuals), *behavioural practice/rehearsal* (n = 10), and *instructions on how to perform*

280   *the behaviour* (n = 8) were the most frequently used (see Table 3).

281   Only one BCT achieved a 100% effectiveness ratio (present in only effective studies):

282   *framing/reframing* (n = 1). Baker and colleagues' (28,29) intervention was the only one to include

283   *framing/reframing*. This was employed via the suggestion to adopt a new perspective on health

284   behaviours through use of motivational interviewing and cognitive behavioural therapy.

285

286   *Feedback on behaviour (66%),* and *self-monitoring* (57%) had the next highest effectiveness ratios*.*

287   *Feedback on behaviour* was present in two effective interventions and was either delivered remotely

288   via a bespoke health promotion website (34) or face-to-face during a one-to-one appointment with

289   the intervention facilitator (28,29). *Self-monitoring of behaviour* was present in all four effective

290   studies. In Chen, Williams and Baker (28,29,34,35) this was done daily by recording pedometer data

291   and in Suen et al (43), participants self-monitored longer term exercise plans based on levels of

292   motivation. Similarly, *adding objects to the environment* (such as pedometers or manuals) was also

293   present in all four effective interventions (28,29,34,35,43), but also in most of the ineffective

294   interventions (31–33,36–41), so whilst frequently used and seemingly effective, this BCT only

295   achieved an effectiveness ratio of 31%.

296

297   **Table 23.** 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%

298

299   *Kaplan et al., 2018 not included.

15

300

301   *Contextual features*

302   No contextual features were identified as unique to the effective interventions, with the exception

303   of one effective intervention (Suen, 2022) (43), which only included female participants. Support was

304   offered in all effective interventions, with three studies (28,29,34,35) offering this on an individual

305   basis throughout the interventions, and one study (43) offering group-based only support

306   throughout the intervention. All effective interventions were delivered either in community mental

307   health settings or with options regarding the setting (34) and were delivered by non-physical activity

308   specialists, but professionals with a therapeutic background with training in delivering the

309   intervention. Three effective studies (28,29,34,35) provided participants with pedometers as a

310   means to track their daily activity levels, and all included an educational component

311   (28,29,34,35,43). These contextual features taken individually were not unique to the effective

312   interventions, but their combination seemed to be for 3 of the 4 effective interventions.

313   *Theories which guided the development of interventions*

314   Ten studies explicitly stated the theoretical underpinnings that had been used to develop PA

315   interventions (see Supporting Information 1). Five interventions had been based on a single theory

316   (32,34–36,41) . These were Social Cognitive Theory (32), Transtheoretical Stages of Change Model

317   (34), Self-Determination Theory (36,41) and the Capability, Opportunity and Motivation Model of

318   Behaviour Change (35). Five interventions had been based on a combination of theories

319   (27,28,31,,38,40,41). These were Motivational Interviewing and Cognitive Behavioural Therapy

320   (28,40), Self-regulation Theory, Self-efficacy and Relapse Prevention Model (27), the

321   Transtheoretical Stages of Change Model, Motivational Interviewing and an Assertive approach (31);

322   and, Mental Contrasting and Implementation Intentions (38). These are all commonly used theories

323   in health behaviour change, but no underpinning theory was more commonly used across the

324   interventions or in the effective interventions compared to those which were not effective.

325   Interventions described by Bartels (33), Masa-Font (37), Suen (43) and Fernandez-Abascal (39) did

326   not provide details of the theoretical approach.

327

328   **Discussion**

329   This systematic review develops emerging literature on interventions aiming to increase PA in

330   people with SMI by identifying the key approaches, components and contextual features that have

331   been employed in the interventions to date. Seventeen papers that report 15 unique interventions

332   were identified, four of which were considered effective. However, overall the evidence base at this

333   time is limited, with 12 of the included studies at overall high risk of bias. While this review is the

334   first to systematically describe the intervention content of PA interventions for people with SMI,

335   small sample sizes and poor reporting of the included interventions restrict our ability to draw firm

336   conclusions about the best way(s) to support PA in this population.

337   The most common approaches to encouraging PA in this population involved providing instruction

338   and the opportunity to practice how to perform physical activity alongside the use of pedometers to

339   track behaviour. Effective interventions were mostly delivered by community mental health teams

340   and professionals not from a physical activity background. Most were delivered face-to-face in a

341   group setting, with the opportunity for one-to-one support.

342   Intervention functions

343   The most common functions of the included interventions were to improve education around PA

344   and environmental restructuring. While both functions were present in all four effective studies,

345   they also featured in some non-effective studies, therefore we cannot draw firm conclusions about

346   their contribution to effectiveness. The only function that achieved a 100% effectiveness was

347   incentivisation, but this was based on its inclusion in just one of the effective interventions. The

348   incentives in Baker et al (28,29) were financial/material in nature and aimed to target motivation.

349　Targeted incentives delivered in line with evidence-based behaviour change frameworks such as

350　COM-B (targeting capability, opportunity, or motivation) have been shown to improve compliance

351　across other health behaviours, however there are concerns about the sustainability of providing

352　incentives long-term as they may be unreliable over time and are associated with over-reliance on

353　extrinsic motivation (44) . Previous reviews have decided to exclude functions and/or BCTs that

354　appear in a single study only (20). As the number of effective interventions in our review was small,

355　we decided to include these components, but their potential effectiveness must be interpreted with

356　caution. Training and modelling were the only functions that were used solely by ineffective

357　interventions, and neither coercion nor restriction have been trialled to date. Coercion has been

358　used as a function within the inpatient setting for adults with SMI (45), but may be less appropriate

359　in the out-patient setting.

360　BCTs

361　We also sought to identify potentially useful BCTs in the published studies. As with intervention

362　functions, the most common BCT, adding objects to the environment, was present in all four

363　effective interventions, but also reported in several of the ineffective interventions. In most studies

364　this included PA sessions, a wearable device and/or a manual. Chen et al (34)also provided text

365　messages. Three BCTs achieved above 50% effectiveness meaning they appeared in more effective

366　studies than ineffective. These were framing/reframing, self-monitoring and feedback on behaviour.

367　Only one BCT achieved 100% effectiveness (framing/reframing) and again this was only present in

368　the Baker study (28,29). Baker et al describe using a combination of CBT and MI which focus on

369　identifying and changing negative and unhelpful thinking patterns, although specific details of how

370　this was done in relation to physical activity is not reported. Self-monitoring was done using

371　pedometers in all but the study by Suen (43) in combination with daily monitoring forms in Baker

372　and Williams (28,29,35). Monitoring and particularly self-monitoring, is one of the most studied

373　behaviour change techniques. It has been shown to be effective in changing a range of behaviours

374   through promoting awareness and engagement (46,47). Feedback on behaviour has also shown to

375   be effective when combined with other strategies such as goal setting and self-monitoring (48,49).

376   Taken together, these four BCTs (adding objects to the environment, framing/reframing, self-

377   monitoring and feedback on behaviour) could provide a useful starting point in the design of future

378   interventions, particularly as together they target all three of the key determinants of behaviour

379   (capability, opportunity and motivation) (13). However, the inclusion of techniques that seem less

380   effective than others based on the limited evidence currently available should not be ruled out

381   especially given interventions with a higher overall number of BCTs appeared to be more effective.

382   Furthermore, our previous research suggests that motivation can be a particular challenge for this

383   population (10), and a study exploring associations between PA, SB and motivation in people with

384   SMI across four countries also highlighted that this is a universally relevant determinant of these

385   behaviours, with autonomous motivation being particularly important (50). Therefore consideration

386   of BCTs that specifically address motivation (for example goal setting, pros and cons, self-talk and

387   positive reinforcement) may be additionally useful for people with SMI (51).

388   Contextual factors

389   Consideration of the context of the intervention is crucial to the potential success of interventions.

390   The TIDieR checklist (21) was used to identify contextual features of published interventions that

391   may be an important consideration during the development of future programmes in this area.

392   Common contextual features, irrespective of effectiveness were the inclusion of an educational

393   component, opportunity to practice and the use of a tool to track PA behaviour such as a

394   pedometer. These are common features of interventions that are designed to encourage increases

395   in levels of PA and are not necessarily specific to this population (52). The majority of the

396   interventions were delivered via community mental health teams. This may be a useful approach,

397   but a recent study has also suggested the need to consider participant preferences for support from

398   other sources (10). Service delivery teams must be involved in a way that facilitates the goal but

399   does not reinforce hierarchical models of care. Although evidence for the effectiveness of individual

400   features was weak, a combination of multiple features could be the key to the creation of an

401   effective intervention (e.g., PA tracking and educational components).

402   The included studies were based on different theories to inform the development of interventions,

403   but there was not a common theory used across the three effective interventions. Although

404   behaviour change theory may be an important consideration for intervention developers, our

405   previous work has also highlighted the importance of the wider context (macro-level structures) in

406   the formation of PA behaviour (micro-level change) (10). For example, an individual with SMI who is

407   motivated to initiate PA may live in a cultural environment (macro-level structure), where some

408   activities are not accessible nor seen as culturally appropriate. None of the reviewed studies

409   attempted to evaluate the effect of the wider environment on individuals' ability to increase their PA

410   levels.

411   In this review we did not consider factors such as intervention environments, providers and

412   participant characteristics as this was beyond the scope of this review, however we recommend that

413   these factors should be explored in future research.

414   *Strengths and limitations*

415   The strengths of this review included the rigorous data extraction, coding and consensus procedures.

416   The review only included RCTs and used effect sizes and effectiveness ratios to examine the

417   evidence for both effective and ineffective interventions in this area. Within the review, we report

418   interventions in comprehensive detail through the application of the standardised TIDieR checklist

419   (21). This enables the replication of successful results and adaptation to other

420   behaviours/populations. The review is one of the first to attempt to unpack the content of effective

421   interventions, by identifying the potentially useful intervention functions, techniques and contextual

422   features that were found in effective interventions compared to ineffective interventions.

423   There are several limitations to this review. Firstly, the possible choice of methods of analysis were

424   restricted due to poor reporting of outcomes in the included papers. Data was not sufficient to

425   perform meta-analyses and similarly we were unable to calculate promise ratios as has been

426   achieved in previous reviews (e.g. (14) as this would require the reporting of both within and

427   between group outcomes, which, in the included papers, were typically either omitted or unreliable.

428   Only 3 of the identified studies examined the impact of the intervention on SB, and none of these

429   were effective. We therefore did not explore the content of these interventions further in the

430   context of SB. There is on-going debate around how sedentary behaviour should be measured which

431   may partially account for why more studies have not explored it as an outcome to date (53).

432   Furthermore, due to the poor reporting and lack of information, 12 of the included studies are at

433   high risk of bias which means that results should be interpreted with caution. This highlights the

434   overall poor quality of research in this area to date as highlighted by both our previous review (12),

435   and another review which focused on PA interventions that included both PA and psychosocial

436   strategies in people living with SMI (54). The latter found limited evidence of effectiveness of these

437   interventions and highlighted significant methodological limitations in this area of research (59).

438   Taken together the findings from these reviews identify a clear need for well-designed, clearly

439   reported and adequately powered RCTs to explore the effectiveness of clearly described

440   interventions to increase PA in this population.

441   In addition, the chosen method of analysis also does not allow the exploration of possible

442   interactions between combinations of intervention functions, BCTs and contextual factors. As the

443   included studies did not systematically vary or isolate individual BCTs, it is difficult to disentangle

444   their independent and combined effects, and makes robust analysis of BCT interactions challenging.

445   Future research, such as factorial trials or qualitative Comparative Analysis (QCA) (55) could support

446   the investigation of synergistic or antagonistic interactions between techniques as the data in this

447   area develops. In some of the current papers, intervention functions and BCTs were either poorly

448   reported or absent, which may have impacted our ability to code and thus draw conclusions across a

449   modest number of studies. Due to the overall poor reporting of studies, we recommend that future

450   studies utilise reporting tools such as the TIDieR framework as a method to report interventions.

451   Poor reporting has been identified as a major limitation of previous reviews of BCTs (49). We note

452   that as a result of frameworks such as TIDieR, reporting of intervention components appears to have

453   improved over time, with more recent studies (particularly Browne and Fernandez (39,41)

454   documenting higher numbers of BCTs which may have affected the results. This better reporting

455   would provide future research with a clearer picture than has been provided thus far of effective

456   intervention functions, BCTs and contextual features for PA intervention development for people

457   with SMI. Future studies should report not only the theories on which interventions are based, but

458   also explain the mechanisms through which the interventions are hypothesised to work.

459   Additionally, with the recent development of the behaviour change technique ontology (56), future

460   studies may wish to consider utilising this approach to synthesise 'what works' within PA

461   interventions for people with SMI.

462   **Conclusions**

463   This systematic review maps the emerging literature on PA interventions for people with SMI by

464   identifying the key approaches and components that have been employed in the interventions

465   trialled to date. We identified intervention features that were unique to effective interventions, but

466   future interventions should not rule out the use of components that were seen in 'non-effective'

467   studies, given the limited evidence base, poor reporting, high risk of bias, and possibility of effects

468   from the combination and/or interaction between BCTs that we were not able to explore.

469   Together with the authors' previous review, the current review suggests that future studies should

470   focus on clear reporting of intervention content and well-designed evaluation studies to improve our

471   understanding of the intervention components (or combinations) that are most effective for

472   increasing PA in people with SMI.

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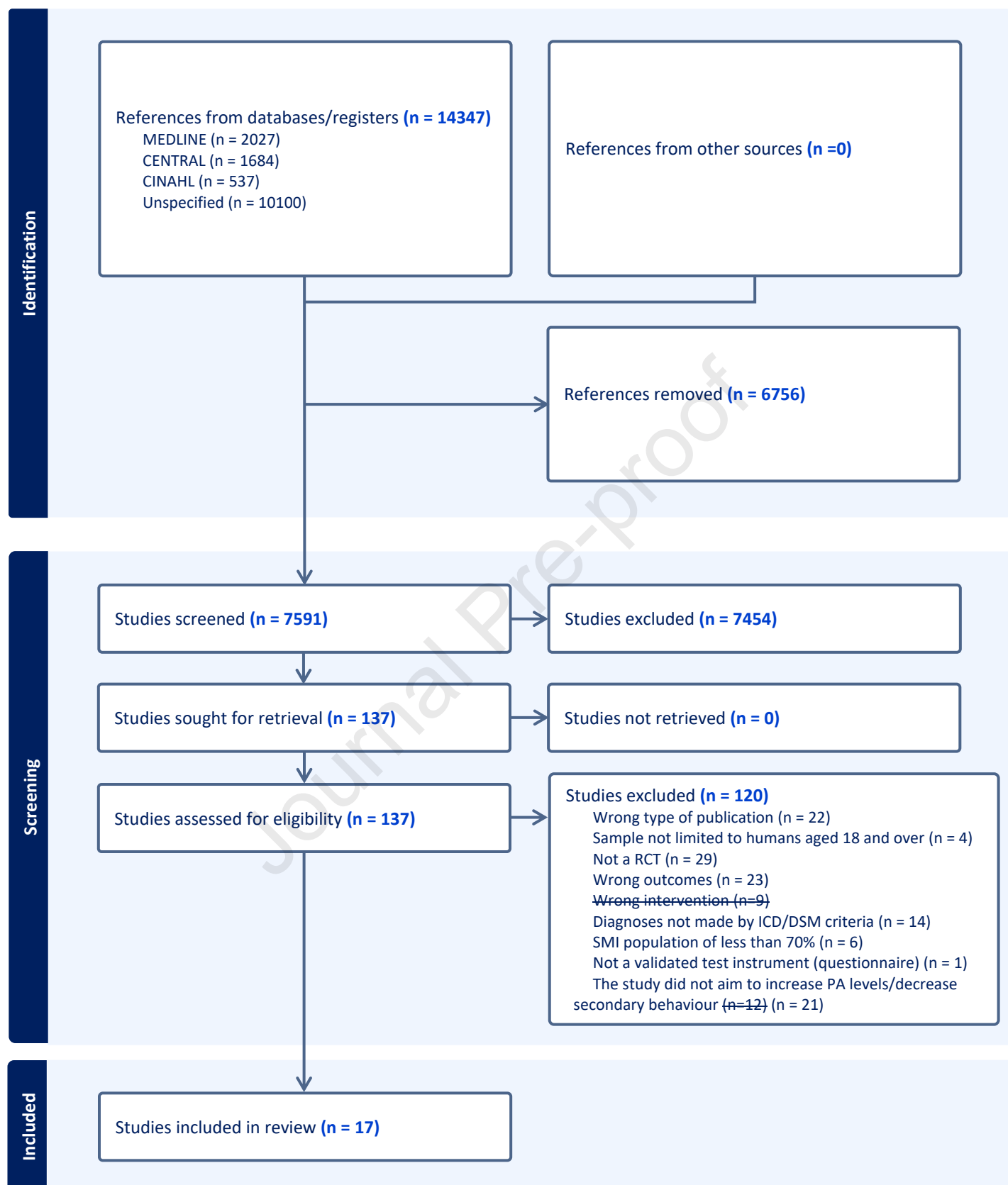552   interventions: template for intervention description and replication (TIDieR) checklist and

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PRISMA Diagram

Identification

References from databases/registers **(n = 14347)**
   MEDLINE (n = 2027)
   CENTRAL (n = 1684)
   CINAHL (n = 537)
   Unspecified (n = 10100)

References from other sources **(n =0)**

References removed **(n = 6756)**

Screening

Studies screened **(n = 7591)**

Studies excluded **(n = 7454)**

Studies sought for retrieval **(n = 137)**

Studies not retrieved **(n = 0)**

Studies assessed for eligibility **(n = 137)**

Studies excluded **(n = 120)**
   Wrong type of publication (n = 22)
   Sample not limited to humans aged 18 and over (n = 4)
   Not a RCT (n = 29)
   Wrong outcomes (n = 23)
   ~~Wrong intervention (n=9)~~
   Diagnoses not made by ICD/DSM criteria (n = 14)
   SMI population of less than 70% (n = 6)
   Not a validated test instrument (questionnaire) (n = 1)
   The study did not aim to increase PA levels/decrease secondary behaviour ~~(n=12)~~ (n = 21)

Included

Studies included in review **(n = 17)**

29th November 2024

covidence

Intention-to-treat

Unique ID	Study ID	Experimental	Comparator	Outcome	Weight	D1	D2	D3	D4	D5	Overall
HIIT	Andersen et al. 2020	PA (HIIT)	Active (exergame)	PA & SB (Accelerometer, objective)	1	+	-	-	+	-	-
Healthy Li	Baker et al. (2015, 2018)	PA (Healthy Lifestyles)	Active (Telephone intervention)	PA & SB (IPAQ, self-report)	1	+	!	+	-	-	-
InSHAPE	Bartel et al. (2015)	PA (Health Promotion Coaching)	Passive (Fitness club membership)	PA (IPAQ, self-report)	1	+	!	+	-	-	-
CHANGE	Speyer et al. (2016) & Jakobsen et al. (2017)	PA (CHANGE)	Active (Care coordination)	PA & SB (Physical Activity Scale, self-report)	1	+	!	+	-	-	-
STEPWISE	Holt et al. (2019)	PA (STEPWISE)	Passive (TAU)	PA (Accelerometer, objective)	1	+	-	+	+	+	-
Rise and S	Kaplan et al. (2018)	PA (Rise and Shine)	Active (Psychoeducation)	PA (Actigraphy, objective)	1	+	!	+	+	!	!
1-way vs.	Chen et al. (2017)	PA (2-way text messages)	Active (1-way text messages)	PA (Pedometer, objective)	1	+	-	-	+	!	-
CAPiCOR	Masa-Font et al. (2015)	PA (CAPiCOR)	Passive (TAU)	PA (IPAQ, self-report)	1	+	!	+	-	+	-
Outdoor C	Ryu et al. (2020)	PA (Outdoor Cycling)	Active (Occupational Therapy)	PA (Pedometer, objective)	1	+	-	-	+	-	-
MCII	Sailer et al. (2015)	PA (MCII)	Active (Goal setting)	PA (IPAQ, self-report)	1	+	!	+	-	-	-
Walk this	Williams et al. (2019)	PA (Walk this Way)	Passive (TAU)	PA & SB (Accelerometer, objective)	1	+	-	+	+	+	-
WALC-S	Beebe et al. (2011)	PA (WALC-S)	Active (TAC)	PA (minutes walked, observer reported)	1	+	-	-	+	!	-
PRIMROSE	Osborn et al. (2018)	PA (PRIMROSE)	Passive (TaU)	PA (IPAQ, self-report)	1	+	+	+	-	!	-
Motivation	Suen et al. (2022)	PA (Motivational Coaching)	Active (Psychoeducation)	PA (IPAQ)	1	+	!	+	-	!	-
Virtual PA	Browne et al. (2023)	PA (Virtual PACE-Life)	Active (Fitbit)	PA (daily pedometer stepcount)	1	+	-	+	+	!	-
Life style	Fernandez-Abascal (2023)	PA (Life style programme)	Active (pedometer)	PA (IPAQ)	1	+	!	+	+	!	!
The LIFEST	Luciano et al. (2022)	PA (The LIFESTYLE programme	Active (brief psychoeducation)	PA (IPAQ)	1	+	!	+	+	!	!

+ Low risk
! Some concerns
- High risk

D1 Randomisation process
D2 Deviations from the intended interventions
D3 Missing outcome data
D4 Measurement of the outcome
D5 Selection of the reported result

- Physical activity tracking alongside educational components is a common approach.
- Behaviour change techniques framing/reframing, feedback on behaviour and self-monitoring were identified as potentially useful.
- Evidence indicates combinations of components may contribute to effectiveness
- Future studies should focus on clear reporting of intervention content.

Declaration of interests

☒ 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.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: