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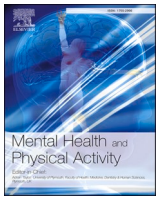

Interventions to increase physical activity and reduce sedentary behaviour in severe mental ill health: How effective are they?'- A systematic review

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ABSTRACT

Background: People with severe mental ill health experience a mortality gap of 15–20 years and one of the main reasons for this is due to preventable physical health conditions. Physical activity can reduce the risk of developing physical health conditions such as diabetes and cardiovascular disease yet people with severe mental ill health are less physically active and more sedentary than the general population.

Methods: A systematic review was conducted to investigate the effectiveness of interventions aimed at increasing physical activity and reducing sedentary behaviour in people with severe mental ill health. The protocol was published with PROSPERO (CRD42021277579). Randomised controlled trials conducted in any country in any setting and published in English with an aim of increasing physical activity or reducing sedentary behaviour were included.

Results: Eleven unique studies were identified for inclusion. Due to the variability between interventions, outcome measures, and time points, it was not possible to conduct a meta-analysis. Effect estimates suggested that three of the interventions were effective at increasing physical activity. However, the certainty of the evidence was rated as low using the GRADE approach.

Conclusions: The evidence on interventions to increase activity shows promise but is insufficiently robust for an intervention to be recommended in clinical guidelines. More high-quality and statistically powered trials are needed to guide best practice and policy.

1. Introduction

People with severe mental ill health (SMI) experience a mortality gap of 15–20 years compared to the general population (Hayes et al., 2017). One of the main reasons for this is preventable physical health conditions, with people with SMI having a 78% increased risk of cardiovascular disease (Correll et al., 2017) and 12% of people with SMI having diabetes (Ward & Druss, 2015). Addressing this widening health inequality is named as a priority in the National Health Service (NHS) Long Term Plan (NHS, 2019). However, the causes of these physical health conditions are multifactorial with health risk behaviours, medication, environmental factors such as pollution, and substandard housing all playing some part (Firth et al., 2019; Ward et al., 2017). One of the ways in which the risk of developing a physical health condition can be reduced is by taking part in physical activity (PA) and reducing the amount of time spent sedentary (i.e., expending energy at a rate ≤1.5 metabolic equivalents while in a sitting, reclining or lying posture) (Booth et al., 2012). There is evidence that PA is effective in the

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prevention and management of cardiovascular disease and the reduction of mortality rates in the general population (Naci & John, 2013). Previous research has demonstrated that people with SMI engage in substantially lower levels of PA and higher levels of sedentary behaviour (SB) than members of the general population (Stubbs et al., 2016). A global meta-analysis revealed that people with SMI engage in significantly less moderate to vigorous PA (MVPA) and total PA per week than the population as a whole and are less likely than those without SMI to meet guidelines of 150 min MVPA per week (Vancampfort et al., 2017). This is concerning because not only is a lack of PA associated with worse health outcomes, but SB is also independently associated with increased risk of cardiovascular disease, type 2 diabetes, and all-cause mortality (Biswas et al., 2015).

Interventions aimed at increasing participation in PA or reducing SB may be focused solely on that goal or they may be part of interventions that tackle multiple risk factors (Conn et al., 2011). They may also involve a variety of approaches such as psycho-education, motivational interviewing or cognitive behavioural therapy (CBT) and practical approaches such as offering opportunities to participate in PA (Conn et al., 2011). These may be delivered in a group or individually, or a combination of both approaches. They may also be delivered face-to-face, over the phone or video call, or web based such as via an App or the Internet. Whilst interventions aimed at increasing PA have been explored in the wider population there have been fewer reviews of interventions to increase PA in people with SMI. A recent systematic review explored the effectiveness of lifestyle interventions for weight, PA and diet in people with any mental health condition and concluded that lifestyle interventions were effective at increasing PA. However this study included people with any mental health condition (including common mental disorders, such as depression) and was not solely limited to people with SMI (Bradley et al., 2022). Previous systematic reviews have identified the mental and physical health benefits to people with SMI in engaging with PA (Firth et al., 2017; Rosenbaum et al., 2014; Vancampfort et al., 2017), and a systematic review in 2018 explored interventions to increase PA in people with SMI (Ashdown-Franks et al., 2018). Ashdown-Franks et al. explored both randomised and non-randomised studies aimed at increasing PA and found low quality evidence of a benefit in 7/16 controlled studies and no change in 9/16 controlled studies (Ashdown-Franks et al., 2018). A 2022 systematic review of effects of PA interventions in people with SMI in secure forensic settings was unable to draw any firm conclusions due to the studies all being small scale with limited follow up (Hassan et al., 2022). In the last few years, several studies have explored interventions to increase PA in people with SMI in both inpatient and community settings. This is a rapidly evolving area and given that there have been additional studies published since the Ashdown-Franks review and that the review team are currently developing an intervention to increase physical activity in people with SMI, we wanted to provide an up to date assessment of the evidence. A further difference between this study and the Ashdown-Franks review is that this study is more focused including solely RCTs. This study therefore aimed to explore the effectiveness of interventions assessed aimed at increasing PA in people with SMI and conduct a meta-analysis.

2. Methods¶

A protocol was registered prospectively on the PROSPERO register of systematic reviews (PROSPERO 2021 CRD42021277579 https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=277579). The review has been reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) 2021 statement (Page et al., 2021).

2.1. Search strategy

We used an electronic search strategy which combined search terms for SMI, PA, SB, and randomised controlled trials (see Supplementary material 1). MEDLINE (PubMed), EMBASE, PsycINFO, CINAHL, NIHR Library and CENTRAL databases were searched for eligible studies from inception year of each database until October 2021. Reference lists of all eligible studies and existing reviews were checked for potentially relevant studies.

2.2. Study types

We included randomised controlled trials (RCTs), including cluster-RCTs, which included interventions that targeted PA or SB in people with SMI, conducted in any country, in either in-patient or community settings and published in English. Due to financial and practical constraints it was not possible to use translation services for non-English studies.

2.3. Participant types

Eligible studies included adults (aged ≥18 years) with a diagnosis of SMI. In line with our previous reviews of interventions targeting modifiable health risk behaviours for this population, we define SMI as schizophrenia or other psychotic disorders, bipolar disorder and depression with psychotic features (NHS England, 2018). To be eligible for inclusion studies need to report that the diagnosis was based on the International Classification of Disease (ICD) or Diagnostic and Statistical Manual (DSM). Studies which included SMI and other diagnoses were eligible for inclusion only if they reported stratified results allowing results for the participants with SMI to be separately extracted or if they provided descriptive statistics demonstrating that more than 70% of participants had SMI.

2.4. Intervention types

We included trials with interventions that explicitly targeted PA or SB, including any mode of PA and any mode of delivery. No restrictions were applied on duration, setting and content of the intervention. For multi-component interventions or multi-behavioural interventions, change in PA or reduction in SB needed to be one of the intervention objectives. Both passive and active control conditions were included, where passive control conditions could be usual care, waiting list control or no treatment conditions. Active control conditions could be alternative cognitive or behavioural approaches. Studies in which no control comparison was reported were not eligible for inclusion.

3. Outcomes

The main outcomes were PA and SB. Only validated measures of PA and SB were eligible for inclusion, and these were based on either data from devices (e.g., pedometers, accelerometers, or inclinometers) or data from questionnaires (i.e., self-report data). Example PA outcomes included steps per day and minutes per day of MVPA, while example SB outcomes included minutes per day of sedentary behaviour, sitting, or screen time. Secondary outcomes were adherence/compliance to the intervention and data on dropouts and adverse events. The endpoints of interest were intervention endpoint and the last available follow-up.

3.1. Exclusion

Studies where more than 30% of the participants did not meet the definition for SMI (schizophrenia or other psychotic disorders, bipolar disorder and depression with psychotic features) were considered

ineligible for this review i.e. studies where more than 30% of the participants had depression without psychotic features or other ineligible diagnoses.

3.2. Study selection

One author performed the searches and exported the references into a review management programme (Covidence) where duplicates were removed. Initial screening of titles and abstracts against inclusion criteria was carried out independently by a small team of reviewers in pairs. The full text of articles identified as possibly relevant following title and abstract screening were screened independently by a small team of reviewers in pairs. Any disagreements were resolved through discussion with a third independent reviewer.

Data from each included article was extracted independently by a small team of reviewers in pairs into a standardised form in Microsoft Excel. Disagreements were resolved by discussion with a third independent reviewer. In cases of missing data, a reviewer contacted the authors of the original papers up to three times over a one month period.

Data extracted from each study included: title, author(s), year, country, setting, funding source, participant characteristics (including eligibility criteria and demographic data), and the number of participant withdrawals and dropouts. Study design data extracted included; number of trial arms, control condition, unit of randomisation, duration, and timing of follow-up(s). Data extracted on outcome measures included how PA and SB were assessed, summary intervention effect size data for PA/SB variables, and summary data for intervention engagement (e.g., adherence to PA targets). Adverse event data was also extracted.

3.3. Risk of bias

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). RoB 2.0 addresses five domains: bias arising from the randomisation process; bias due to deviations from intended interventions; bias due to missing outcome data; bias in measurement of the outcome; and bias in selection of the reported result. Two authors independently applied the tool to each included study for each of the three main outcome types (self-reported PA/SB, 'open' device-measured PA/SB [with 'open' referring to the device giving immediate feedback about the behaviour to the participant], and 'closed' device-measured PA/SB ['closed' = no feedback]) and recorded supporting information and justifications for judgements of risk of bias for each domain (low; high; some concerns). Any discrepancies in judgements of risk of bias or justifications for judgements were resolved by discussion. Following guidance (Sterne et al., 2019), an overall summary risk of bias judgement (low; some concerns; high) for each outcome was produced, whereby the overall risk of bias for each study was determined by the highest risk of bias level recorded across the domains.

3.4. Analysis

Data were synthesised in both narrative and tabular formats. Although meta-analyses were planned a priori (and where appropriate), the included studies provided varying outcomes and data that could not be combined in a meta-analysis. Therefore, a meta-analysis was not preformed, however summary outcome data and effect estimates have been presented. The effect size (0.273) used in the SPACES (Supporting Physical Activity through Co-production in people with Severe mental ill health, NIHR 201618) sample size calculation was considered the minimum clinically important difference and acted as a reference for whether an intervention was effective or not.

Two authors independently assessed the certainty of the evidence using the GRADE approach (Guyatt et al., 2011). The certainty of evidence for a particular outcome was assessed as high, moderate, low, or very low and a 'Summary of findings' table has been produced.

For the secondary outcomes, the data has been summarised in tabular format alongside a narrative overview of the findings.

4. Results

The searches identified 6890 unique records, of which 86 full texts were screened for eligibility following title and abstract screening. 13 studies met the inclusion criteria (based on 11 unique interventions with 1189 participants), see Fig. 1.

4.1. Characteristics of the included studies

The smallest study recruited 15 participants (Chen et al., 2017) and the largest study recruited 428 participants (Jakobsen et al., 2017; Speyer et al., 2016). Two studies were conducted in England (Holt et al., 2019; Williams et al., 2019), one in Norway (Andersen et al., 2020), one in Australia (Baker et al., 2015), one in the USA (Bartels et al., 2015), one in Denmark (Speyer et al., 2016), one in Taiwan (Chen et al., 2017), one in Spain (Masa-Font et al., 2015), one in Korea (Ryu et al., 2020), one in Germany and Switzerland (Sailer et al., 2015), and one did not clearly state the country (Kaplan et al., 2018). Four of the studies recruited participants with schizophrenia or schizoaffective disorder (Andersen et al., 2020; Bartels et al., 2015; Holt et al., 2019; Speyer et al., 2016), two studies recruited participants with schizophrenia (Ryu et al., 2020; Sailer et al., 2015), two studies recruited participants with schizophrenia and bipolar disorder (Chen et al., 2017; Williams et al., 2019), one study recruited people with schizophrenia, schizoaffective disorder and bipolar disorder (Baker et al., 2015), one study recruited participants with schizophrenia, schizoaffective disorder, bipolar disorder and major depression (Bartels et al., 2015), and one study recruited participants with bipolar disorder only (Kaplan et al., 2018). Of these studies, seven were in community mental health settings (Andersen et al., 2020; Bartels et al., 2015; Chen et al., 2017; Holt et al., 2019; Masa-Font et al., 2015; Speyer et al., 2016; Williams et al., 2019), one was in psychiatric hospitals and community health teams (Ryu et al., 2020), one was in psychiatric hospitals (Sailer et al., 2015), one was in community mental settings and general practitioner surgeries (Baker et al., 2015), and one did not state the setting (Kaplan et al., 2018).

Five of the studies involved a group intervention (Andersen et al., 2020; Holt et al., 2019; Masa-Font et al., 2015; Ryu et al., 2020; Williams et al., 2019) and six of the studies involved an individual intervention (Baker et al., 2015; Bartels et al., 2015; Chen et al., 2017; Kaplan et al., 2018; Sailer et al., 2015; Speyer et al., 2016). In seven of the studies, the intervention was compared to an active control (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., 2016) and in four of the studies the intervention was compared to treatment as usual (Chen et al., 2017; Holt et al., 2019; Masa-Font et al., 2015; Williams et al., 2019). An intervention focusing on PA was delivered in six of the studies (Andersen et al., 2020; Bartels et al., 2015; Ryu et al., 2020; Sailer et al., 2015; Williams et al., 2019), whilst a multicomponent intervention with one of the components being PA was delivered in four of the studies (Baker et al., 2015; Holt et al., 2019; Masa-Font et al., 2015; Speyer et al., 2016). The final study (Kaplan et al., 2018) involved one session of an intervention aimed at increasing PA to reduce sleep inertia.

One of the included studies was a pilot study which aimed to explore the feasibility and acceptability of the intervention (Williams et al., 2019).

4.2. Follow-up and outcomes

Although all studies included in this review had PA as one of the outcomes, there was only one study in which the primary outcome was a PA outcome (Chen et al., 2017). Of the other studies, one had multiple primary outcomes of which PA was one (Masa-Font et al., 2015) and in six studies the primary outcome was not a PA outcome (Baker et al.,

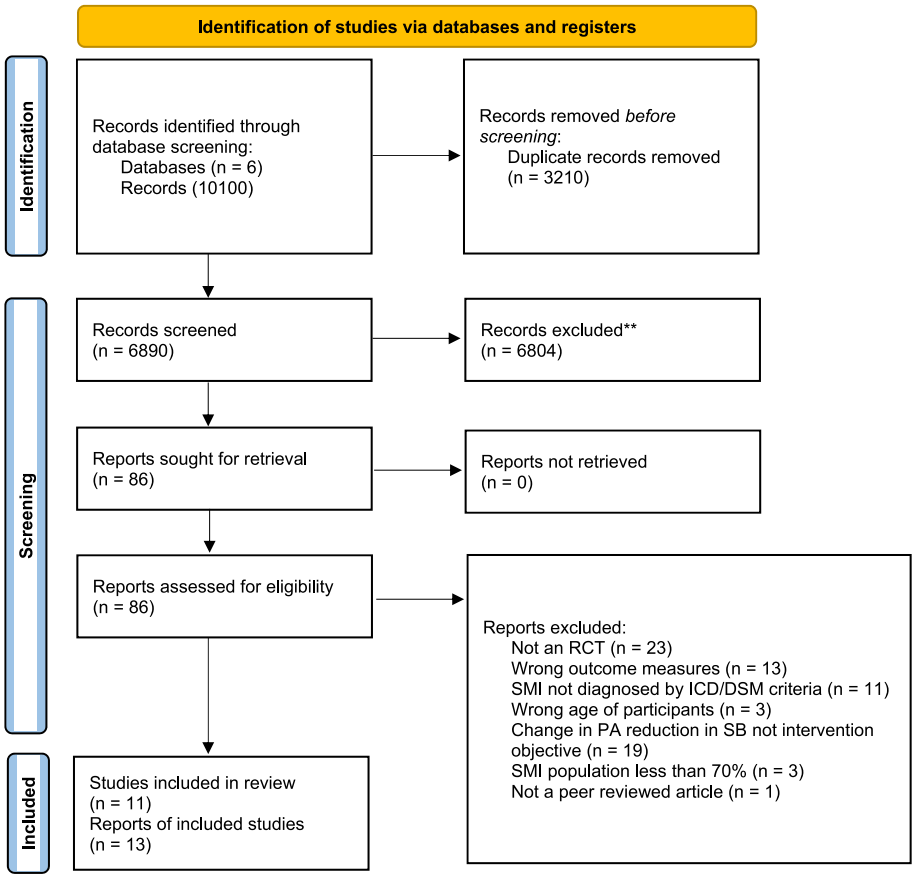

Fig. 1. PRISMA diagram.

2015; Bartels et al., 2015; Holt et al., 2019; Sailer et al., 2015; Speyer et al., 2016; Williams et al., 2019). The primary outcome was not clearly stated in three studies (Andersen et al., 2020; Kaplan et al., 2018; Ryu et al., 2020).

The PA outcomes reported included MVPA measured by accelerometer (Andersen et al., 2020; Holt et al., 2019; Kaplan et al., 2018; Williams et al., 2019) or physical activity scale (Speyer et al., 2016) vigorous physical activity measured by IPAQ (Bartels et al., 2015), daily step count measured by pedometer (Chen et al., 2017; Ryu et al., 2020), weekly MET measured by IPAQ (Masa-Font et al., 2015; Sailer et al., 2015) and walking time measured by IPAQ (Baker et al., 2015). Only three studies reported SB as an outcome.[29,30,31]

4.3. Methodological quality and bias in the included studies

The risk of bias for all included studies is shown in Fig. 2. All the studies except one (Kaplan et al., 2018) were assessed as being at 'high risk' overall, Kaplan (Kaplan et al., 2018) was assessed as having 'some concerns'. The main sources of concern were potential bias due to the selection of the reported result, where six studies were at 'high risk' (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 two had 'some concerns (Chen et al., 2017; Kaplan et al., 2018), measurement of the outcome where five 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

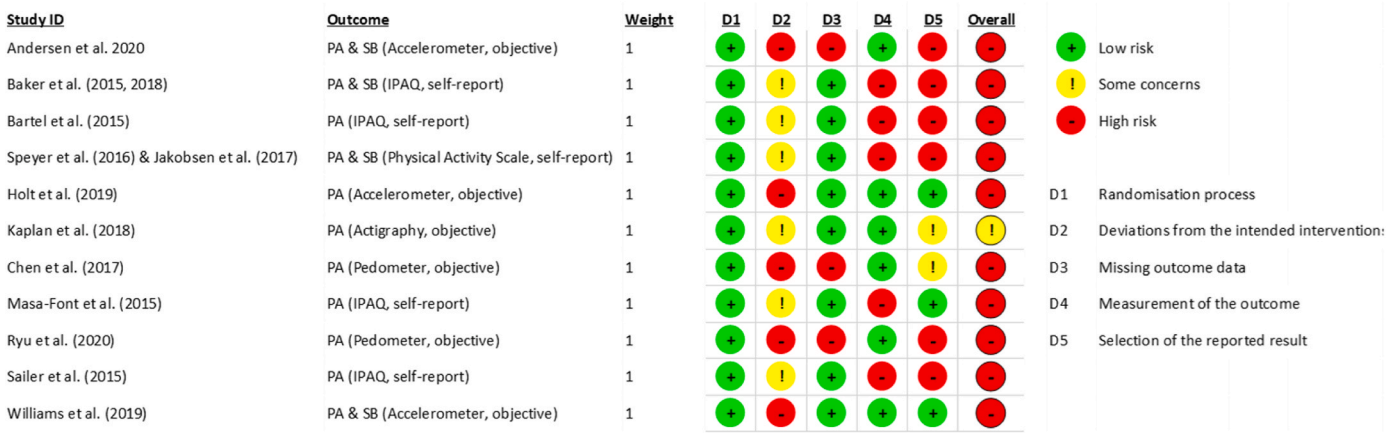

Fig. 2. Risk of bias.

Table 1
Characteristics of included studies.

Study/design	Population	intervention	physical activity outcome
Andersen 2020 RCT	Norway Outpatient psychiatric clinics (n = 82 (n = 43 HIIT; n = 39 exergame)) Schizophrenia spectrum disorder 39% female HIIT, 38% female exergame, mean age 35 HIIT, 37 exergame	HIIT vs exergame (video game). High intensity interval training delivered face to face by mental health care rightly with and without physical activity training. Twice weekly for 45 min for 12 weeks consisting of an 8 min warm up, 4 × 4 min intervals with 3 min active pauses, and 5 min cool down.	Total PA measured by accelerometer (Actigraph GT3X+) at baseline and 12 weeks
Baker 2015 & Baker 2018 RCT	Australia Community mental health teams and GPs (n = 235 (n = 122 healthy lifestyle intervention, n = 113 telephone intervention)) Schizophrenia spectrum or bipolar disorder 41% female, mean age 41.6 84% Australian born	Healthy Lifestyle intervention targeting PA, diet and smoking cessation. Multi-component lifestyle intervention utilising motivational interviewing and CBT delivered individually, face to face by psychologists experienced in mental disorders. One hour sessions with 7 weekly sessions, then 3 x fortnightly sessions then 6x monthly sessions for 9 months Vs telephone intervention	Walking time measured by IPAQ at baseline,15 weeks, 6, 12, 18, 24, 30 and 36 months
Bartels 2015 RCT	Schizophrenia, schizoaffective, bipolar disorder, or major depression (n = 210 (n = 104 health coaching; n = 106 gym membership 55% female health coaching, 47% gym membership, mean age 43.5 health coaching, 44.3 gym membership 54% white, 32% Black, 20% Latino	health promotion coaching vs gym membership. Health coaching involved a personalised fitness plan delivered individually face to face by mental health case managers with a basic certificate in fitness training or certified fitness trainers with an interest in working with people with mental disorders. Delivered once a week for 45–60 min for 12 months.	Vigorous activity measured by short form IPAQ at baseline, 3, 6, 9, 12 and 18 months
Chen 2017 RCT	Taiwan Community Mental health Teams (n = 18, (n = 7 two-way texts, n = 8 one way texts*)) Schizophrenia or affective disorder 86.7% female two-way text messaging, 71.4% one-way text messaging *18 participants recruited but three withdrew during intervention text only provides allocation for remaining 15 participants who finished study	Two-way text messaging vs one-way text messaging. Telehealth promotion website plus a pedometer to measure step count with data uploaded weekly, a health manual and text messages. Delivered individually with access to the website for 12 weeks.	Daily step count measured by pedometer (Omron HJ 720 ITC) at baseline and weekly for 12 weeks. Participants were not blinded to step count.
Holt 2019 RCT	England Mental health trusts (n = 414 (n = 208 STEPWISE, n = 206 usual care)) Schizophrenia, schizoaffective disorder or first episode psychosis 46.4% female STEPWISE, 53.7% female usual care, mean age 40 STEPWISE, 40.1 usual care 86.1% white European STEPWISE, 86.9% white European control	STEPWISE intervention targeting PA and diet vs usual care. Structured lifestyle education programme using behaviour change theory delivered in a group face to face by registered mental health professionals and support workers and healthcare assistants with individual support. 2.5 h sessions delivered once a week for 4 weeks then at 4, 7 and 10 months and fortnightly 10 min telephone support for 12 months.	MVPA measured by accelerometer (GENEActiv) at baseline, 6 and 12 months.
Kaplan 2008 RCT	Not clearly stated (n = 40 (n = 20 Rise and Shine, n = 20 psychoeducation)) Bipolar I disorder and insomnia 70% female Rise and Shine and 65% female psychoeducation, mean age 39.3 Rise and Shine, 35.4 psychoeducation, 68.4% white rise and shine, 65% psychoeducation	Rise and Shine intervention vs psychoeducation. Rise up morning routine consisting of 6 components each with a behavioural instruction. Delivered individually face to face by a doctoral candidate or licensed psychologist. 1 × 60 min session.	MVPA measured by accelerometer (Actiwatch AW-64) one week prior to the intervention and one week after.
Masa-font 2015 RCT	Spain Mental health teams (n = 332 (n = 169 CAPiCOR, n = 163 usual care)) Schizophrenia, schizoaffective disorder or bipolar disorder 45.0% female CAPiCOR, 45.4% Female usual care, mean age 46.3 CAPiCOR, 47.1 usual care	CAPiCOR intervention targeting diet & PA vs usual care. Walking with recommendations for intensity and safe practices in physical activity. Walking sessions delivered face to face in a group by mental health nurses Dietary advice delivered by mental health or primary care nurses. Walking sessions were delivered twice weekly sessions for 12 weeks with a 40 min initial session with subsequent sessions up to an hour and 20 min of dietary advice.	Total weekly MET and walking weekly MET measured by IPAQ at baseline and 3 months.
Ryu 2020 RCT	Korea Local psychiatric hospitals and CMHTs (n = 60, (n = 30 outdoor cycling, n = 30 occupational therapy)) Schizophrenia 50% female outdoor cycling, 43.3% female OT, mean age 38.7 outdoor cycling, 39 OT	Outdoor cycling vs occupational therapy. Outdoor cycling programme delivered face to face in a group by professional cyclists educated about bike riding, medical doctors, nurses, physical activity staff and social workers. Moderate intensity once a week for 1.5 h for 16 weeks.	Daily activity measured by pedometer (Yamax Digiwalker SW-200) at baseline and weeks 4, 8, 12 and 16. Participants were not blinded to step count.
Sailer 2015 RCT	Germany and Switzerland Psychiatric hospitals (n = 36, (n = 19 MCII, n = 17 goal intention)) Schizophrenia 36.8% female MCII, 76.5% female, mean age 30.9	Mental contrasting and implementation intentions (MCII) Vs goal intention. Mental contrasting listing 3 positive outcomes participants associated with attending exercise sessions and 3 obstacles with a plan developed for tackling the most significant obstacle. MCII delivered face to face individually with group face to face jogging sessions delivered by trained therapists. MCII 1 x a week for 3 weeks, jogging 2 x a week for 30 min for duration of hospital stay.	IPAQ measured at baseline and 4 weeks

(*continued on next page*)

Table 1 (*continued*)

Study/design	Population	intervention	physical activity outcome
Speyer 2016 & Jakobsen 2017 RCT	Denmark Setting not clearly stated (n = 428, (n = 138 CHANGE, n = 142 care coordination, n = 148 usual care) Schizophrenia, schizoaffective disorder or persistent delusional disorder 55.1% female CHANGE, 57.7% female CARE, 54.7% female usual care, mean age 37.8 CHANGE 39.5 CARE and 38.5 usual care	CHANGE intervention targeting PA, diet and smoking cessation Vs care coordinator vs usual care. Lifestyle coaching with care coordination delivered individually face to face by health professionals with clinical experience in psychiatry. The care coordination was delivered by psychiatric nurses. Weekly lifestyle coaching for 12 months with care coordination as needed.	MVPA measured using the Physical Activity Scale at 12 months and two years
Williams 2020 RCT	England Community mental health team (n = 40 (n = 20 walk this way, n = 20 usual Care)) Schizophrenia, bipolar disorder or psychosis 45% female, mean age 43 27.5% white	Walk this way intervention targeting PA vs usual care plus written information on the benefits of being active. Education session on strategies to sit less and health coaching addressing barriers to reducing sedentary behaviour and increasing physical activity plus a walking group. Delivered by people with experience of a healthy living programme for people with SMI, with health coaching delivered individually. Walking delivered face to face in a group. 1 x initial education session, 8 × 30 min fortnightly health coaching sessions	MVPA measured by accelerometer (GENEActiv) at baseline, 17 weeks and 6 months

et al., 2016) and potential deviation from the stated intervention where five studies were at high risk (Andersen et al., 2020; Chen et al., 2017; Holt et al., 2019; Ryu et al., 2020; Williams et al., 2019), the rest all had 'some concerns'. Three of the studies were assessed as 'high risk' for missing outcome data (Andersen et al., 2020; 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.

Our inspection of trial registries and inquiries with area experts did not identify any unpublished completed trials.

4.4. Primary outcome

Due to heterogeneity between the included studies (intervention type, outcome measure, comparator and population) it was not possible to conduct a meta-analysis as originally planned (see Table 1). Therefore, a narrative overview is provided. Primary PA and SB outcomes are reported in Table 2 (for a full list of PA outcomes see Supplementary Material 2). Where possible we have calculated an effect size for the included studies for the PA primary outcome and SB. Kaplan (Kaplan et al., 2018) has not been included in these calculations as the outcome (change in activity levels an hour after waking) was deemed by the review group (and in accordance with our protocol) to be too different to the outcomes in other studies to be meaningful. For the time point either at the end of the intervention or in cases where the PA or SB outcome wasn't measured at the end of the intervention (Baker et al., 2015) the time point closest to the end of the intervention was chosen. Taking the point estimate of the effect size of >0.273 SD as positive, of the eight studies we were able to calculate an effect size for PA outcome for, the following studies were deemed to give a positive result in favour of the intervention in terms of increasing levels of PA (effect sizes are given in brackets). Baker (Baker et al., 2015) (0.346), Chen (Chen et al., 2017) (0.695), Williams (Williams et al., 2019) (0.844). Bartels (Bartels et al., 2015) stated in the text that there was a significant increase in PA in favour of the intervention however the numbers reported at 12 month follow up in Table 2 in Bartels do not match this statement. We were able to calculate an effect size for all three studies that had a SB outcome however none of the effect sizes were positive in favour of the intervention.

A summary of the certainty of evidence is given in Table 3. The evidence was rated as very low for PA and SB. Both outcomes were downgraded two levels for very serious risk of bias and one level for inconsistency. SB was also downgraded one level for imprecision.

4.5. Secondary outcomes

Details of the secondary outcomes are given in Table 4.

4.6. Adverse events

Only three studies reported adverse events. Of these, Chen (Chen et al., 2017) reported no adverse events, whilst Holt (Holt et al., 2019) reported a similar number of adverse events in both arms of the trial but provided no further details. Speyer (Speyer et al., 2016) reported the percentage of participants who had either a psychiatric or somatic hospital admission. There were fewer psychiatric and somatic hospital admissions in the intervention arm than both the control and care coordination arms. Due to differences in the way adherence was reported it is difficult to provide a narrative overview of adherence.

5. Discussion

In this review we sought to examine the effectiveness of interventions aimed at increasing PA or decreasing SB in people with SMI. We identified 11 unique RCTs, however due to the heterogeneity between studies and high risk of bias in the included studies it was not possible to conduct a meta-analysis or provide any clear recommendations. Although the primary aim in six of the studies included in our review was to increase PA only one study clearly stated that the primary outcome was measurement of PA. It is therefore important that future studies, particularly those with multiple aims make the primary outcome of the study clear. None of the RCTs identified had a primary aim of decreasing SB. Four of the studies involved a multi-behavioural lifestyle intervention, with one of the aims being to increase PA or decrease SB, however due to the differences in terms of the study designs and outcomes it was difficult to compare these studies with those that had a sole aim of increasing PA. For example, in one of the studies (Baker et al., 2015), the time point at which PA was targeted was guided by the participant. Furthermore, where an increase in PA was a secondary aim or one of a suite of aims there might be less attention given to increasing PA which in turn might produce a lesser effect in terms of increasing PA. There were no serious exercise–related adverse events reported in any of the included studies, however, eight of the studies did not include any details of adverse events.

Of the included studies, three studies (Baker et al., 2015; Chen et al., 2017; Williams et al., 2019) were deemed to be effective at increasing PA, where an effect size of >0.273 was regarded as being effective. Two of which involved an objective measure.(Chen et al., 2017; Williams

Table 2
Physical activity and sedentary behaviour outcomes.

Study outcome and timepoint	Intervention	Control	Effect size (95% CI)
Andersen 2020	Mean (SD)	Mean (SD)	
MVPA mins per day	20 (12), *n=35*	28 (24), *n=35*	0.129 (−0.438 – 0.696)
Baseline	26 (20), *n=23*	23 (26), *n=25*	
12 weeks (intervention end)			
SB (hours per day)	8.2 (1.6), *n=35*	8.2 (1.6), *n=35*	0.125 (−0.442 – 0.692)
Baseline	8.3 (1.6), *n=23*	8.1 (1.6), *n=25*	
12 weeks (intervention end)			
Baker 2015	**Mean (SD)**	**Mean (SD)**	
Walking time (mins per week)	231.1 (373.7), *n=109*	231.9 (413.8), *n=105*	0.346 (0.008–0.683)
Baseline	289.4 (622.9), *n=79*	217.4 (326.1), *n=86*	
15 weeks	353.1 (546.1), *n=70*	209.2 (206.6), *n= 67*	
12 months[a]			
Total sitting time (mins per week)	2855.2 (1646.2), *n=108*	2952.6 (1726.7), *n=106*	−0.020 (−0.353 – 0.312)
Baseline	2496.4 (1531.1), *n=74*	2932.0 (1591.1), *n=86*	
15 weeks	2722.6 (1456.1), *n=70*	2751.6 (1435.3), *n=69*	
12 months[a]			
Bartels 2015	**Mean (SD)**	**Mean (SD)**	
IPAQ vigorous MET mins	464.6 (640.1), *n=52*	167.0 (595.7), *n=46*	−0.057 (−0.441 – 0.328)
3 months	994.5 (2341.2), *n=52*	53.9 (175.3), *n=46*	
6 months	694.8 (2013.4), *n=51*	255.0 (667.8), *n=49*	
9 months	393.7 (1048.8)[c], *n=52*	484.3 (1992.6)[c], *n=52*	
12 months (intervention end)			
Chen 2017	**Mean (SD)**	**Mean (SD)**	
Steps per day	7876.2 (779.2), *n=7*	7524.7 (1252), *n=8*	0.695 (−0.350 – 1.739)
Baseline	9050.2 (1309.0), *n=7*	8286.3 (1888.4), *n=8*	
1 month	8797.7 (2056.1), *n=7*	8301.8 (2909.7), *n=8*	
Two months	9256.8 (2396.4), *n=7*	7459.3 (2739.2), *n=8*	
Three months (intervention end)			
Holt 2019	**Mean (SD)**	**Mean (SD)**	
MVPA (mins per day)	13.3 (16.8), *n=207*	11.0 (13.1), *n=205*	0.176 (−0.038 – 0.389)
Baseline	13.3 (20.4), *n=178*	8.8 (12.6), *n=180*	
3 months	15.4 (21.7), *n=167*	11.8 (19.3), *n=173*	
12 months (intervention end)			
Masa-Font 2015	**Mean (SD)**	**Mean (SD)**	
Total METs (weekly)	1340.6 (1508.4), *n=166*	1453.5 (1460.6), *n=160*	0.014 (−0.203 – 0.232)
Baseline	1532.0 (1539.6), *n=166*	1405.4 (12431.9), *n=160*	
3 months (intervention end)			
Ryu 2020	**Mean (SD)**	**Mean (SD)**	
K-PASE	118.62 (67.1), *n=30*	107.4 (65.8), *n=30*	Insufficient data
Baseline	Not reported	Not reported	
Sailer 2015			
IPAQ score on discharge[b]	Not clearly stated	Not clearly stated	Insufficient data
Speyer 2016	**Mean (SD)**	**Mean (SD)**	
MVPA (hours per week)	2.5 (4.0), *n=138*	2.5 (4.0), *n=148*[d]	0 (−0.232 – 0.232)
12 months (intervention end)			
Williams 2020	**Mean (standard error)**	**Mean (standard error)**	
MVPA (mins per day)	126.4 (15.2), *n=16*	97.1 (10.9), *n=17*	0.844 (0.106–1.582)
Baseline	166.5 (22.9), *n=14*	105.1 (14.6), *n=17*	
17 weeks (intervention end)	186.9 (20.0), *n=8*	109.9 (23.4), *n=13*	
6 months			
SB (mins per day)	577.2 (9.8), *n=16*	549.2 (19.1), *n=17*	−0.901 (−1.643 – 0.159)
Baseline	520.9 (36.2), *n=14*	637.9 (30.4), *n=17*	
17 weeks (intervention end)	508.2 (19.4), *n=8*	661.2 (33.5), *n=13*	
6 months			

[a] Intervention endpoint between 15 week and 12 month follow-up.
[b] Participants received intervention for different lengths of time.
[c] Figures quoted in table in article, in text it states that there was a significant difference in PA in the intervention group.
[d] Usual care, see supplementary file 1 for data on care coordination.

et al., 2019). None of the included studies were found to be effective at decreasing SB. All of the studies that were found to be effective involved a range of SMI diagnoses, which suggest that interventions may be effective across a range of diagnoses. All of the effective studies were delivered in a community setting with the duration of the intervention ranging from 12 to 30 weeks, only one of the studies involved a component which involved the participants taking part in physical activity, whilst one of the studies was a multicomponent intervention where PA was encouraged but there was not an active PA element, the remaining study involved text messages to encourage PA and a pedometer to monitor step count. All three of the studies found to be effective were at overall high risk of bias, two due to deviations from the intended intervention, one of these was also at high risk of bias for missing outcome data and the remaining study was at high risk of bias for measurement of the outcome and selection of the reported result.

A previous review has drawn similar conclusions to our review (Ashdown-Franks et al., 2018). This is despite their being some important differences between our review and the review by Ashdown-Franks. Firstly, our review did not include participants with major depressive disorder, secondly we only included RCTs in our review whereas Ashdown-Franks included non-randomised studies, thirdly nine of the 11 studies we identified were not included in the Ashdown-Franks review, five because they were published after the Ashdown-Franks review and four because of differences in inclusion criteria.

Table 3
Summary of findings.

Outcome	Effect	Number of participants (studies)	Certainty = of the evidence
PA	Three studies showed an increase in PA demonstrated by positive effect size, whilst two studies showed a small increase in PA but without a positive effect size. Three studies showed no increase in PA	1759 (8 randomised trials)	VERY LOW Very serious risk of bias, downgrade two levels; Some inconsistency exists, downgrade one level.
SB	One study showed a small decrease in SB and two studies showed no decrease in SB.	357 (3 randomised trials)	VERY LOW Rating downgraded due to very serious risk of bias (two levels), inconsistency (one level) and imprecision (one level).

Table 4
Secondary outcomes.

Study	Adherence	Adverse events
Andersen 2020	The number of sessions attended Intervention: 18.1 (4.3) Control: 19.2 (2.0)	Not reported
Baker 2015	Mean number of sessions attended Intervention: 9.2 (6.0), Control: 12.4 (5.2)	Not reported
Bartels 2015	Percentage of participants who attended ≥80% of the sessions Intervention: 54%, Control: 70%	Not reported
Chen 2017	83.0% had a reply rate of >50% to texts	No adverse events
Holt 2019	53.6% attended ≥ three foundation sessions and ≥ one booster session. 22.7% attended all sessions	Adverse events were similar in both arms
Kaplan 2018	80% completed the checklist	Not reported
Masa-Font 2015	49% attended 60% of the sessions	Not reported
Ryu 2020	Not reported	Not reported
Speyer 2016	60% attended ≥21/42 sessions.	Psychiatric hospitalisations: Intervention: 18.8%, care coordination: 33.8%, Control: 24.3% Somatic hospitalisations: Intervention: 12.3%, care coordination: 17.6%, Control: 16.2%
Sailer 2015	Mean number of sessions attended Intervention: 58.8% (12.5), Control l: 40.0 (30.2)	Not reported
Williams 202	13/20 attended≥ 1 coaching session 8/20 joined the walking group	Not reported

It is worrying that despite the increase in need for interventions addressing SB reported in Ashdown-Franks review we were not able to identify any studies whose primary aim was to address SB. A systematic review by Vancampfort (Vancampfort et al., 2017) found that people with SMI spent 476.0 min per day sedentary and were significantly more sedentary than age- and gender-matched healthy controls. This is of particular concern given a survey of health risk behaviours of people with SMI during the Covid-19 pandemic found that nearly half of the respondents reported a decrease in PA during the pandemic (Peckham et al., 2021). However, there is an on-going debate about how best to measure SB.

Overall, our impression is that the current evidence for the effectiveness of interventions to increase PA is promising however, it is not yet sufficiently robust to make specific clinical recommendations. Our findings are consistent with one other recent review of interventions to increase PA and reduce SB in people with SMI (Ashdown-Franks et al., 2018). There is a need for well-designed, clearly reported and adequately powered RCTs to explore the effectiveness of interventions to increase PA and decrease SB. The studies included in this review were all at a high overall risk of bias which means that even for studies that showed a positive effect in terms of increasing PA it is not possible to be confident in the result. It is therefore important that future studies ensure that the report according to CONSORT guidelines (Schulz et al., 2010). Furthermore, when reporting interventions authors need to make explicit the theoretical underpinning that they have used to inform the development of the interventions and if multiple techniques are used to provide a detailed breakdown on those which data mine behaviour change. The TIDEieR checklist is a useful tool to guide the reporting of interventions to ensure that all the details of the intervention are adequately reported. However current reporting of interventions is inconsistent and often inadequate. Using the TIDieR checklist and making the theoretical underpinning explicit will be helpful in improving reporting standards.

The strengths of this review are that the conduct and reporting of the study was consistent with existing guidelines. These included prospectively registering the protocol, carrying out screening, data extraction and analysis in duplicate and using a predetermined template for data extraction. Furthermore, to maximise chances of identifying all eligible studies, a comprehensive search strategy alongside checking trial registries and reference lists, and consulting experts in the field was employed. Despite this, the review has several limitations. Firstly, we were not able to identify any eligible studies where reducing SB was the primary aim of the study and secondly the certainty of the evidence is very low and, as a small number of studies were identified with high heterogeneity, we were unable to conduct a meaningful meta-analysis for any of the evaluated outcomes. Thirdly, we were unable to perform any analyses to assess for publication bias. Finally, we acknowledge that there is not an agreed standard for measuring SB and therefore no conclusive results regarding SB can be drawn based on the current state of knowledge on the subject.

6. Conclusion

The aim of the systematic review was to assess the effectiveness of interventions to increase PA and decrease SB in people with SMI. The evidence on interventions to increase PA shows promise but is

insufficiently robust for an intervention to be recommended in clinical guidelines. However, the evidence may suggest that PA appears to be safe and without adverse effects. Due to insufficient evidence it is not possible to draw any conclusions regarding the effectiveness of interventions to reduce SB. More high-quality and statistically powered trials are needed to guide best practice and policy. Furthermore, research is needed to determine the feasibility of effectiveness of interventions aimed at reducing SB in people with SMI.

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Declaration of competing interest

Given their role as an Editorial Board Members Stubbs B. had no involvement in the peer-review of this article and had no access to information regarding its peer-review. All other 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.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mhpa.2023.100547.

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