Title

Factors prospectively associated with physical activity and dietary related outcomes in people with severe mental illness: a systematic review of longitudinal studies.

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Abstract

Understanding factors that contribute towards physical activity and diet outcomes are important for health improvement in people with severe mental illness. Cross-sectional findings on factors associated with diet and physical activity outcomes provide limited information on what predicts changes or long-term outcomes in lifestyle behaviours in people with severe mental illness. A systematic review was therefore conducted to identify prospective studies with quantitative data on baseline factors associated with follow-up diet or physical activity related outcomes. MEDLINE, EMBASE, PsycINFO, CINAHL Plus and grey literature databases were searched from inception to March 2018. From 6921 studies, 5 were eligible for physical activity related outcomes and 2 for diet related outcomes. The follow-up duration was 4 weeks to 24 months and participants were mostly diagnosed with schizophrenia. Older age was commonly related to better physical activity related outcomes, whilst higher negative symptoms were related to poorer-related outcomes. Physical activity intentions and gender were unrelated to physical activity outcomes. There was a lack of data on factors influencing dietary outcomes. Although there were some common factors predictive of physical activity including older age and negative symptoms, more high-quality research is needed to determine the effect of sociodemographic, mental health, social, clinical, lifestyle and other factors on both physical activity and dietary outcomes.

Keywords: schizophrenia; bipolar; exercise; diet; quantitative; prospective; cohort.

Abbreviations: CVD (cardiovascular disease); BMI (body mass index); ROB (risk of bias)

1. Introduction

People with severe mental illness including schizophrenia, bipolar disorder or other psychotic conditions have a higher risk of cardiovascular disease (CVD) and are at increased risk of dying younger from CVD (Correll at al., 2017; De Hert al., 2011). CVD is associated with high cholesterol, blood pressure, blood glucose and obesity; all of which are common in people with severe mental illness (Osborn et al., 2008). Such factors may be modified through healthy lifestyle choices (De Hert et al., 2011). In cross-sectional studies people with severe mental illness show evidence of poorer lifestyle behaviours including unhealthy dietary habits and physical inactivity, for example greater consumption of saturated fats, less fruit and fibre and high levels of sedentary behaviour (Dipasquale et al., 2013; Stubbs et al., 2016a; Stubbs et al 2016b; Vancampfort et al., 2016; Vancampfort et al., 2017).

Research in the general population has shown that both physical activity and a healthy diet are important for long-term weight loss and other health benefits (Johns et al., 2014). Therefore, targeting these behaviours may contribute towards a reduction in CVD risk and early mortality rates in people with severe mental illness. A recent review on the effectiveness of physical activity interventions to increase physical activity and reduce sedentary behaviour in people with severe mental illness reported unclear results (Franks et al., 2018). Therefore, more high-quality interventions are needed to determine whether physical activity interventions can be effective for promoting physical activity in this population. However, we need to understand factors that contribute towards both dietary and physical activity behaviours. This knowledge may help to adapt interventions to suit individuals, increasing the uptake of healthy dietary and physical activity choices.

A number of systematic reviews explored cross-sectional associations with physical activity in people with severe mental illness. Older age, being male, objective measures of physical activity were associated with light physical activity levels and higher depressive symptoms were associated with low vigorous physical activity levels in people with schizophrenia (Stubbs et al., 2016a). A review in bipolar disorder reported that low physical activity levels were associated with older age and higher BMI (Vancampfort et al., 2016). One review considered psychosis and identified that older age and objective measures were associated to sedentary behaviour (Stubbs et al., 2016b). Vancampfort et al (2017) considered physical activity levels and associated factors in schizophrenia, bipolar and major depressive disorder. Lower moderate or vigorous physical activity was associated with higher antidepressant intake, a diagnosis of schizophrenia, being unemployed, being male, lower cigarette intake, higher BMI and lower cardiorespiratory fitness.

Factors associated with dietary behaviours in people with severe mental illness are less researched and there are no reviews which consider both diet and physical activity together in people with severe mental illness. A systematic review containing over 700 studies in the general population suggested that diet may contribute more than physical activity towards weight loss (Miller et al., 1997). Therefore, additional work in this field is particularly important to generate knowledge into the reduction of CVD risk factors in people with severe mental illness. To our knowledge, only one review addressed factors associated with dietary behaviours in people with schizophrenia and reported a number of inconsistencies (Dipasquale et al., 2013). It was unclear whether socioeconomic status, gender, smoking status and antipsychotics were related to dietary behaviours.

Most of the reviews in this area have been based on findings from cross-sectional studies. Though some reviews attempted to include prospective studies, meta-regressions or narrative interpretations did not contain prospective associations (Dipasquale et al., 2013; Stubbs et al., 2016a; Stubbs et al., 2016b; Vancampfort et al., 2016; Vancampfort et al., 2017). Cross-sectional studies do not allow temporal associations or long-term behavioural outcomes to be determined since outcomes and exposures are determined concurrently. Further, previous reviews did not consider factors associated with physical activity or dietary related changes, yet this information would be valuable to consider in people with severe mental illness. Prior reviews in physical activity were restrictive in their consideration of physical activity. Searches were additionally restricted by limited search terms and the omission of grey literature such as theses. Additionally, previous physical activity reviews did not specifically search for studies exploring predictors of physical activity. It is possible that important associations may have been missed if the data were too limited to combine in analyses. The latest search was conducted in

November 2011 for diet and it is possible that additional prospective studies may have been identified since then (Dipasquale et al., 2013). Further, formal assessments of methodological quality were not reported in both physical activity and diet reviews, therefore the strength of the findings are unclear as well as how future studies may improve on the quality of studies.

To our knowledge, no other systematic reviews have searched specifically for predictors of longitudinal changes in physical activity or diet with: broad definitions of physical activity and diet outcomes, robust search terms, rigorous search strategies and methodological quality assessments. We therefore addressed two specific research aims: 1) to identify factors prospectively associated with physical activity related outcomes and 2) to identify factors prospectively associated with dietary outcomes in people with severe mental illness.

2. Methods

The protocol for this review was published in PROSPERO registration number CRD42018098998. There were no deviations from the original protocol. This review was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and Assessing the Methodological Quality of Systematic Reviews (AMSTAR) guidelines (Moher et al., 2009; Shea et al., 2007).

2.1. Inclusion criteria.

Eligible studies included: a) participants where the majority of the sample contained people with a diagnosis of schizophrenia, persistent delusional disorder, schizoaffective disorder, bipolar affective disorder, psychosis (including first episode), psychotic depression or other psychotic disorder, b) adults aged 18+, c) inpatients and/or outpatients, d) quantitative data where the exposure was collected before the outcome within observational prospective study designs, embedded cohort studies within RCTs where we were able to separately assess the intervention and predictor variable effects on the outcome, or where the intervention had no effect on the outcome at the latest possible follow-up point. We had no language limitations in searches; however, limited resource prevented us from translating papers that were not in English (see supplementary material for details of studies excluded on the basis of language) and e) literature published in academic journals and/or unpublished academic theses.

We excluded the following study designs: a) cross-sectional and case-control studies reporting only baseline data and b) pre and post intervention studies where all participants received the intervention with no comparator arm. We also excluded conference proceedings and abstracts due to limited content.

2.2. Information sources and search strategy.

Date or language restrictions were not applied to the search strategy. Systematic searches were performed separately for physical activity and diet outcomes. We searched MEDLINE, EMBASE, PsycINFO and CINAHL Plus from inception to 16th March 2018. We identified relevant theses by searching OpenGrey, EthOS, British Library e–theses online service, ProQuest Dissertations and theses and DART-Europe E-theses portal from inception to 14th March 2018.

A comprehensive search strategy was developed under the guidance of an information scientist (J.F.) at the Royal Free Medical Library, London. The format of the search strategy included: population (“severe mental illness”, “schizophrenia”, “psychosis” etc.), outcome (“physical activity”, “diet” etc.) and study design (“prospective”, “longitudinal” etc.). See the supplementary material for an example search strategy syntax using MEDLINE. Search terms were developed and identified via: a) scoping searches to identify relevant articles and prior literature reviews and b) discussing relevant terms with the review team with expertise in medical, mental health and statistics (K.W., D.O., L.M. & J.R.). We used a combination of medical subject headings (MeSH) and free text words, accounting for variations in spellings.

For included studies, we conducted backwards and forwards citation searches using either Google Scholar or Web of Science.

2.3. Study selection.

Following removal of duplicates, all articles were screened by one reviewer (S.H.) by title and abstract applying the eligibility criteria with an inclusive approach to obtaining full texts where uncertainty arose. Full-text articles were then screened independently by two reviewers (S.H. & J.R.) who then compared findings and agreed on the final included studies.

2.4. Outcomes.

We were interested in the following outcomes: a) any physical activity related outcomes and b) any dietary related outcomes. Where reported, we were interested in identifying change in physical activity and diet related outcomes from baseline scores. Measures used to assess outcomes were not restricted. This was to determine the different approaches adopted within studies and the effect on findings. However, we only included studies where validated outcome measures were employed. Measures validated in people with severe mental illness were preferred. However as there has been very limited research on the validation of measures in this population, the review included outcome measures that had been validated in the general population (Soundy et al., 2014).

2.5. Data extraction.

The data were extracted by one reviewer (S.H) and 10% was independently double-coded by a second author (J.R) to determine accuracy. There was 100% consistency between items extracted by both reviewers. The data extraction form contained the following items: a) study characteristics, b) methodology, c) participant characteristics, d) intervention (where applicable) and setting and e) outcomes (end time point taken, measurement of behavioural outcome, total of predictors/correlates employed in analysis and description, method of measuring exposure variables, analytical method employed to identify predictors, significant and non-significant associations with effect sizes, p-values and 95% confidence intervals (CI) where applicable). We contacted authors where data were missing or ambiguous.

2.6. Quality assessment.

We assessed the quality of studies by employing the Newcastle-Ottawa risk of bias (ROB) for cohort studies (Wells et al., 2009). The tool comprised of a rating system whereby a maximum of 9 stars could be achieved overall, indicating the highest quality. The tool assessed three main methodological aspects including: selection, comparability and outcome (Wells et al., 2009)

2.7. Data analysis.

We identified a variation between studies in terms of how exposures and outcomes were measured and the statistical analysis of associations; consequently, it was not possible to pool data in the form of a meta-analysis and a narrative analysis was adopted.

3. Results

3.1. Selection process.

Figures 1 and 2 display the PRISMA flow diagrams documenting the selection process. In physical activity searches, a total of 3424 articles and 228 theses were screened by title and abstract. A total of 111 articles and 16 theses were screened at full text, of which 107 articles and 15 theses were excluded. Five articles were deemed eligible for inclusion (Arbour-Nicitopoulos et al., 2017; Beebe et al., 2011; Gardner-Sood, 2015; Jakobsen et al., 2018; Nyboe et al., 2016).

In diet searches, 3764 articles and 77 theses were screened at the title and abstract stage. Of these, 85 articles and 71 theses were screened at full-text. A total of 84 articles and 70 theses were excluded, with 2 articles eligible for inclusion (Gardner-Sood, 2015; Jakobsen et al., 2018).

[Figures 1 and 2 here]

3.2. Study characteristics.

The characteristics of the included studies are reported in Table 1.

[Table 1 here]

3.2.1. Physical activity.

We identified three longitudinal studies (Arbour-Nicitopoulos et al., 2017; Gardner-Sood, 2015; Nyboe et al., 2016); one prospective study embedded into an RCT (Jakobsen et al., 2018) and one RCT that had no effect on the outcome of walking behaviour combining treatment arms in analysis of physical activity correlates (Beebe et al., 2011). We therefore treated Beebe et al. (2011) as an embedded prospective study. Studies were conducted in Canada, (Arbour-Nicitopoulos et al., 2017), the United States (Beebe et al., 2011), Denmark (Jakobsen et al., 2018; Nyboe et al., 2016) and the United Kingdom (Gardner-Sood, 2015). Follow-up durations ranged from one month to 2 years. The sample sizes ranged from 97 to 428 participants, with an age range of 29 to 47 years. We did not identify any studies that included people with bipolar disorder; the majority of participants were diagnosed with either schizophrenia (16-100%) and/or schizoaffective disorder (10-71%). Two studies included both inpatients and outpatients (Arbour-Nicitopoulos et al., 2017; Jakobsen et al., 2018), two studies included outpatients only (Beebe et al., 2011; Nyboe et al., 2016) and one study included inpatients only (Gardner-Sood, 2015). Patients were mostly classed as unemployed or on social security benefits across the majority of studies (62-97%). In the assessment of physical activity related outcomes, three studies employed objective measures (Arbour-Nicitopoulos et al., 2017; Beebe et al., 2011; Jakobsen et al., 2018) and two studies employed subjective self-reported measures (Gardner-Sood, 2015; Nyboe et al., 2016). We did not identify any studies measuring change in physical activity related outcomes from baseline values.

3.2.2. Diet.

Two studies measured long-term dietary outcomes (one- and two-years follow-up) and contained participants with schizophrenia where the majority were classed as unemployed. Gardner–Sood's (2015) sample contained those diagnosed with a first episode of psychosis and were therefore younger than Jakobsen et al's (2018) sample (mean 29.7 versus 38.6 years). Both studies employed self-reported measures to determine dietary behaviour including: The Dietary Instrument for Nutrition Education (DINE) to determine saturated fat, fat and fibre intake and the Dietary Quality Score (DQS) measuring fish, fruit, vegetable and fat intake (Gardner–Sood, 2015; Jakobsen et al., 2018). No studies measured change in dietary related outcomes.

3.3. Quality assessment.

For physical activity related outcomes, the highest scores were achieved among two studies including scores of 8 and 7 on the Newcastle-Ottawa Scale (Jakobsen et al., 2018, Nyboe et al., 2016). Three studies were considered to be of lower methodological quality scoring a total of 6, 5 and 4 (Arbour–Nicitopoulos et al., 2017; Beebe et al., 2011; Gardner–Sood 2015). For dietary related outcomes, Jakobsen et al (2018) scored a total of 7 and Gardner-Sood (2015) was lower quality scoring 4.

3.4. Findings.

3.4.1. Physical activity related outcomes.

Table 2 summarises the findings reported from the 5 included studies.

[Table 2 here]

<u>Sociodemographic factors</u>

Sociodemographic characteristics considered as predictors of outcome across studies were limited; age, gender and employment were the only factors that were addressed in analyses. However, most (*n*=4) considered at least one of these factors.

Age

Older age was predictive of meeting Canadian guidelines for moderate-vigorous physical activity (*OR*=0.92, *95% CI*=0.87 to 0.96, *p*=0.001, *n*=99) (Arbour–Nicitopoulos et al., 2017). Similarly, in Beebe et al.'s (2011) study of walking behaviour, older age correlated with greater number of minutes walked at 4 months (*r*=0.26, *p*=0.01, *n*=78).

Gender

Gender was not predictive of meeting guidelines for moderate-vigorous physical activity in Arbour–Nicitopoulos et al. (2017) (*OR*=0.38, *95% CI*= 0.13 to 1.09, *p*=0.07, *n*=99). Similarly, it was reported that gender was not predictive of physical activity in Nyboe et al. (2016); however, supporting data were not provided for this.

Employment

Although the majority of participants across studies were classed as unemployed or on social security benefits, only one study considered employment as a predictor of physical activity related behaviour. Jakobsen et al. (2018) found being in any type of employment was significantly predictive of higher cardiorespiratory fitness (*β*=2.00, *95% CI*=0.24 to 3.78, *p*=0.02, *n*=428).

<u>Mental health related factors</u>

Two studies explored the effects of antipsychotic medication dosage, illness duration, negative and positive symptoms on physical activity related outcomes.

Antipsychotic medication dosage

Jakobsen et al. (2018) reported that overall dose of olanzapine, clozapine or quetiapine did not significantly predict cardiorespiratory fitness (*β*=−0.70, *95% CI*=−1.60 to 0.20, *p*=0.13, *n*=428). However, it is unclear whether medication adherence was considered. Additionally, the measure was based on self-reported medication history which may have been subject to recall error. Further, medication dosage or type may have changed within the two-year period from baseline reported medication history. It is therefore unclear how this may have affected the findings.

Duration of illness

The effect of illness duration (in years) on cardiorespiratory fitness was explored in one study (Jakobsen et al., 2018). There was a negative association between longer duration of illness and lower levels of cardiorespiratory two years post baseline (*β*=-0.11, *95% CI*= -0.22 to <0.01, *p*=0.04, *n*=428).

Negative and positive symptoms

Jakobsen et al. (2018) reported that a decrease in cardiorespiratory fitness was predicted by negative symptoms (*β*= -1.23, *95% CI*=-1.98 to -0.47, *p*=<0.01, *n*=428). Similarly, Nyboe et al. (2016) reported that low physical activity levels were predicted by negative symptoms (*β*=-0.88, *95% CI*=-1.48 to -0.29, *p*<0.001, *n*=99).

The effects of positive symptoms on cardiorespiratory fitness were also explored in Jakobsen et al. (2018), however, no significant associations were reported (*β*=−0.41, *95% CI*=−0.95 to 0.12, p=0.13, *n*=428).

<u>Social factors</u>

Two studies independently considered whether social factors including social support and friendship may be predictive of physical activity related outcomes (Arbour-Nicitopoulos et al., 2017; Jakobsen et al. 2018). Neither social support (*OR*=0.74, *95% CI*= 0.47 to 1.16, *p*=0.18, *n*=99), nor having friends or not/ spending time with friends in the last week (*β*=1.50, *95% CI*= -1.00 to 3.99, *p*=0.24, *n*=428) was predictive of physical activity related outcomes.

Clinical and lifestyle characteristics

Studies individually measured the effect of clinical and lifestyle characteristics on physical activity related outcomes. This included: level of global functioning, previous physical activity behaviour, cognition and BMI.

Functioning

One study reported that cardiorespiratory fitness was predicted by higher global levels of functioning (*β*=0.24, *95% CI*=0.11 to 0.37, *p*<0.01, *n*=428) (Jakobsen et al., 2018)

Previous physical activity behaviour

Baseline self-reported moderate-vigorous physical activity was not predictive of moderate-vigorous physical activity at 4 weeks in Arbour–Nicitopoulos et al. (2017) (*OR*=1.00, *95% CI*=1.00 to 1.00, *p*=0.94, *n*=99).

Health behaviour intentions

Two studies explored whether intentions for physical activity predicted later physical activity outcomes. Intentions of moderate-vigorous physical activity were not predictive of meeting guidelines for physical activity (*OR*=1.39, *95% CI*= 0.95 to 2.04, *p*=0.09, *n*=99) in Arbour–Nicitopoulos et al. (2017). Gardner-Sood (2015) also found that physical activity outcomes at 12 months and physical activity intentions at baseline were not significantly correlated (*r*=0.19, *n*=70). Gardner–Sood (2015) additionally reported that physical activity outcomes at 12 months were not correlated with diet intentions at baseline (*r*=0.11, *n*=70).

Cognition

Jakobsen et al. (2018) reported that higher levels of cardiorespiratory fitness were predicted by higher levels of cognitive functioning (*β*=0.14, *95% CI*=0.06 to 0.21, *p*<0.01, *n*=428).

BMI

It was reported that moderate-vigorous physical activity was predicted by lower BMI levels (*OR*=0.90, *95% CI*= 0.84 to 0.98, *p*=0.01, *n*=99) in Arbour-Nicitopoulos et al. (2017).

Theoretical factors

The primary aim of two studies was to explore the predictive ability of theoretical constructs of physical activity related behaviours (Arbour–Nicitopoulos et al., 2017; Gardner–Sood 2015).

One study explored whether meeting guidelines for moderate–vigorous physical activity could be predicted by constructs of the Health Action Process Model. Arbour–Nicitopoulos et al. (2017) reported that action planning (*OR*=1.12, *95% CI*= 0.69 to 1.83, *p*=0.64, *n*=99), coping planning (*OR*= 0.88, *95% CI*= 0.54 to 1.43, *p*=0.61, *n*=99) or maintenance self-efficacy (*OR*=1.60, *95% CI*= 0.90 to 2.82, *p*=0.11, *n*=99) did not significantly predict meeting guidelines for moderate–vigorous physical activity.

Another study assessed whether aspects of the Protection Motivation theory related to health risk perceptions was correlated with physical activity outcomes at 12 months. Gardner–Sood (2015) reported that manageability of threat (*r*=0.2, *n*=70), perceived personal vulnerability (*r*= -0.11, *n*=70), self-efficacy perceptions of diet (r=0.12, *n*=70), self-efficacy perceptions of exercise (*r*=0.17, *n*=70) were not correlated with physical activity outcomes at 12 months.

3.4.2. Dietary related outcomes.

The exposures measured within both the studies we identified varied and it was therefore not possible to explore consistencies between the two studies (Gardner–Sood, 2015; Jakobsen et al., 2018). Jakobsen et al. (2018) measured the effects of sociodemographic, mental health related and clinical and lifestyle characteristics on overall dietary intake, whereas Gardner-Sood (2015) explored the impact of theoretical constructs on components of diet. Most of the reported associations were not significant. Both studies employed self-reported measures of diet requiring recall of weekly and daily food intake.

Sociodemographic characteristics

Employment

Jakobsen et al. (2018) reported that any type of employment was not a significant predictor of dietary quality scores (*β*=0.19, *95% CI*= −0.21 to 0.54, *p*= 0.28, *n*=428).

Mental health related factors

Negative and positive symptoms

Neither negative symptoms (*β*=-0.12, *95% CI* = -0.27 to 0.04, *p*=0.14, *n*=428) nor positive symptoms (*β*=0.04, *95% CI*= -0.07 to 0.15, *p*=0.47, *n*=428) were predictive of dietary quality scores (Jakobsen et al., 2018).

Antipsychotic medication dosage

Antipsychotic medication dosage including olanzapine, clozapine or quetiapine was not predictive of dietary quality scores at 2 years (*β*=0.02, *95% CI*= -0.17 to 0.20, *p*=0.87, *n*=428) (Jakobsen et al. 2018).

Duration of illness

Dietary quality scores were not predicted by duration of illness (in years) (*β*=-0.01, *95% CI*= −0.04 to 0.01, *p*=0.23, *n*=428) but the method of determining illness duration was unclear (Jakobsen et al., 2018).

Social factors

Friendship

Having friends or not/ or spending time with friends in the last week did not significantly predict dietary quality scores (*β*=0.28, *95% CI*= −0.23 to 0.78, *p*=0.28, *n*=428) (Jakobsen et al., 2018).

Clinical and Lifestyle characteristics

Global assessment of functioning

The only significant finding reported by Jakobsen et al. (2018) was the association between global assessment of functioning and dietary quality scores. Higher global assessment of functioning predicted higher dietary quality scores (*β*= 0.03, *95% CI* = 0.004 to 0.05, *p*=0.02, *n*=428). Although the association may appear weak, global assessment of functioning was assessed on a scale from 1-100.

Cognition

Cognition was not a significant predictor of dietary quality scores (*β*=0.11, *95% CI*= −0.03 to 0.26, *p*=0.13, *n*=428) (Jakobsen et al., 2018).

Theoretical factors

As previously noted, theoretical constructs in Gardner–Sood (2015) were not based on validated measures, and findings should therefore be interpreted with caution.

There was no association between manageability of perceived threat and saturated fat intake (*r*= -0.04, *n*=70) unsaturated fat intake (*r*=0.04, *n*=70) and fibre intake (*r*= 0.12, *n*=70) at 12 months.

Perceived personal vulnerability was not associated with saturated fat intake (*r*= 0.11, *n*=70), unsaturated fat intake (*r*=-0.02, *n*=70) and fibre intake (*r*=-0.06, *n*=70).

There was no correlation between self-efficacy for diet and saturated fat intake (r= 0.03, *n*=70), unsaturated fat intake (*r*=0.02, *n*=70) and fibre intake (*r*=0.12, *n*=70) at 12 months.

Self-efficacy for physical activity and saturated fat intake (*r*= -0.11, *n*=70), unsaturated fat intake (*r*=0.07, *n*=70) and fibre intake (*r*= 0.07, *n*=70) were also not correlated.

There was no correlation between diet intentions and saturated fat intake (*r*=0.02, *n*=70), unsaturated fat intake (*r*=0.20, *p*>0.05, *n*=70) and fibre intake (*r*=0.09, *n*=70). Similarly, there was no association between physical activity intentions and saturated fat intake (*r*=-0.05, *n*=70), unsaturated fat intake (*r*=0.17, *n*=70) and fibre intake (*r*= 0.11, *n*=70).

4. Discussion

Despite variations in the way physical activity outcomes were assessed, we were able to identify some consistencies within the data. Older age was commonly associated with higher physical activity levels or cardiorespiratory fitness and higher negative symptoms were associated with lower cardiorespiratory fitness or physical activity levels (Arbour–Nicitopoulos et al., 2017; Beebe et al., 2011; Jakobsen et al., 2018). Gender and physical activity intentions were not consistently related to physical activity related outcomes (Arbour–Nicitopoulos et al, 2017; Nyboe et al., 2016). There was very little evidence on factors predicting dietary outcomes, and observed associations were largely not statistically significant (Gardner–Sood, 2015; Jakobsen et al., 2018).

Our finding that older age was related to engaging in some form of activity including walking and moderate–vigorous physical activity suggests that younger people with severe mental illness may be less inclined to carry out any form of physical activity (Arbour–Nicitopoulos et al., 2017; Beebe et al., 2011). This may suggest a need for interventions that target physical activity in younger groups. It may be that those with more established schizophrenia may have a greater understanding of their illness and health risks and therefore may be more likely to engage in some form of physical activity as a way of preventing health problems. It may also be that with age, patients developed other physical health problems such as diabetes, hypertension or experienced CVD events and therefore received stronger advice on uptake of physical activity by health professionals. Thus, increasing knowledge of health risks of low physical activity among younger people with severe mental illness may be important for promoting physical activity uptake. However, when considering physical activity in other reviews, older age was cross-sectionally linked to less physical activity, more sedentary behaviour and less vigorous and intense forms of physical activity in people with schizophrenia and psychosis (Stubbs et al., 2016a; Stubbs et al., 2016b). This is also consistent with evidence from the general population (Harvey et al., 2015). In our review Nyboe et al (2016) also found older participants engaged in more walking, which is considered a less vigorous form of physical activity. Further clarification of predictors of particular types of physical activity longitudinally are required to disentangle inconsistent findings and determine strategies for increasing different types of physical activity uptake in different age groups.

Gender was unrelated to physical activity, unlike other reviews where light and lower moderate or vigorous physical activity were observed in men (Stubbs et al., 2016a; Vancampfort et al., 2017). This may be explained by small sample sizes and lack of statistical power in included studies (Arbour–Nicitopoulos et al., 2017; Nyboe et al., 2016). It is theoretically plausible that physical activity outcomes may differ between men and women with severe mental illness. Ochoa et al. (2012) reported that affective symptoms were more common in women, whilst negative symptoms were more common in men. Vancampfort et al. (2012) reported in cross-sectional studies that negative symptoms were linked to lower physical activity levels, perhaps explaining previous review cross-sectional findings that men were less likely to engage in vigorous physical activity and more likely to partake in light physical activity (Stubbs et al., 2016a; Vancampfort et al., 2017). Therefore, further exploration of gender differences in long-term physical activity related outcomes with larger sample sizes may be required with a consideration of the role of mediators in explaining differences.

Our finding that higher negative symptoms scores were related to lower cardiorespiratory fitness and lower physical activity differed to prior review findings (Jakobsen et al., 2018; Nyboe et al., 2016). A review conducted by Stubbs et al. (2016a) based on cross-sectional data reported no association between negative symptoms and physical activity. This may be explained by use of different measures to determine negative symptoms across studies and therefore further longitudinal investigation is required.

Physical activity outcomes were unrelated to physical activity intentions at baseline across two studies (Arbour-Nicitopoulos et al., 2017; Gardner-Sood, 2015). In contrast, Farhom and Sorensen (2016) reported that physical activity was associated with physical activity intentions in cross-sectional studies. The difference between findings may be explained by intention being associated with current physical activity (and possibly short-term physical activity) but not sustained longer-term physical activity. Rhodes and de Brjuin et al. (2013) identified that in prospective studies conducted in the general population, the intention-physical activity behaviour gap was 46%. Alternative behavioural constructs may therefore require more consideration including an understanding of motivation levels and self-efficacy when considering sustained physical activity.

Our findings related to diet outcomes were limited and it was not possible to compare findings across the two studies we identified (Gardner–Sood 2015; Jakobsen et al. 2018). All but one of the factors measured were statistically unrelated to diet related outcomes. This may be due the self-reported nature of diet outcomes; a common method employed among research studies (Dipasquale et al., 2013). Gardner-Sood (2015) and Jakobsen et al (2018) assessed the quantity of food consumed weekly or daily through one-off recall which is problematic. Dietary assessment methods using self-reported questionnaires are dependent on the cognitive and mental status of patients and can therefore be subject to error. Perhaps the use of anthropometric measures such-as weight, fat mass, fat-free mass and dietary biomarkers may yield more reliable information regarding dietary status.

Most of the studies we identified in physical activity (n=3) relied on objective measures and a number of statistically significant findings were reported across these studies. Some of the objective measures included accelerometers and pedometers. However, pedometers fail to provide information on physical activity energy expenditure, are limited to measuring ambulatory activity and are less accurate when measuring slower (such as shuffling) or faster (such as running) speeds (Feito, 2013). Nevertheless, there was also some previous evidence to suggest that objective measures of physical activity were better measures of physical activity compared to self-reported measures (Stubbs et al., 2016a; Stubbs et al., 2016b). This was further reinforced in a recent study which showed that levels of self-reported physical activity did not differ between controls and people with schizophrenia, however accelerometer data showed lower levels of physical activity among people with schizophrenia compared to controls (Firth et al., 2018). This may imply that people with severe mental illness inaccurately estimate the amount of physical activity they perform, raising questions regarding the reliability of self-reported physical activity.

It is also important to note that the studies included in this review adjusted for a limited range of confounders, for example few adjusted for socio-economic status or ethnicity which may be important confounding factors, and there is potential for unmeasured confounding. Additionally, studies employing correlation analysis were unable to adjust for confounding variables. The findings should therefore be treated with caution.

4.1. Limitations and strengths.

There were some limitations to this review. First, we were unable to perform meta-analyses due to the limited number of studies in this field. Secondly, all findings were limited in that none of the studies explored predictors of changes in diet/ physical activity over time or accounted for baseline values. Thirdly, we included studies regardless of the level of ROB. However, we used ROB assessments to provide recommendations for future research. We adopted an inclusive approach and therefore included a broad range of physical activity outcomes. We were able to identify similarities within the literature despite the differences between measures employed. We also adopted a vigorous approach when searching for literature including: a broad range of search terms, consensus meetings to affirm search terms, backwards and forwards citation searches and grey literature database searches. As a

result of these approaches, we identified more prospective studies compared to other reviews in this area.

4.2. Future research.

There is a need for future methodologically robust prospective research, determining factors that are prospectively associated with long–term physical activity and diet outcomes, before any strong conclusions can be drawn. Based on our findings we recommend that future prospective studies: 1) consider people with bipolar disorder as there were no studies identified with this group and explore whether differences may be apparent across different severe mental illness diagnoses and settings, 2) explore methods of measuring diet and physical activity change from baseline to follow-up and factors associated with change, 3) employ standardised well-validated measures and methods in determining exposures to permit comparability across studies, 4) where possible use objective measures of outcomes in physical activity and explore stronger methods of measuring diet such as the use of daily food diaries over a range of time or involvement from family or friends, 5) contain large sample sizes to permit analysis of a larger range and number of predictor variables and account for potential confounding factors and 6) explore mechanisms behind findings and therefore mediators that may influence the relationship between predictor and outcome variables.

5. Conclusions

Although we identified a paucity of longitudinal studies examining the effect of baseline factors associated with either physical activity or dietary related outcomes in people with severe mental illness, some consistencies were emerging within physical activity related outcomes including older age and better physical activity related outcomes as well as higher negative symptom scores and poorer physical activity-related outcomes. However, studies on dietary outcomes were very limited. We identified a series of methodological limitations within studies, which should be addressed in future research.

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Conflicts of Interest

None.

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Tables and Figures

Table 1. Study characteristics and methodological quality

Author	Study design setting and location	Assessment of physical activity related outcome	Assessment of dietary related outcomes	Study duration	Participant characteristics	Newcastle – Ottawa risk of bias quality assessment			
						Selection	Comparability	Outcome	Total
Arbour-Nicitopoulos et al., (2017)	Prospective, inpatients and outpatients, Canada.	Accelerometer worn over 7 days, moderate – vigorous physical activity (150 minutes of physical activity over a week)	-	4 weeks	• *n*=132 • 67% schizophrenia, 32% schizoaffective disorder, 1% psychosis. • 59% male. • 59% unemployed, 3% student, 28% part-time, 2% full-time, 2% retired, 6% other. • Mean age (years) 41.5 SD 11.7 • Psychiatric score (BRPS) mean 33.5 SD7.3 • BMI mean 31.2 SD 7.8	3/4	2/2	1/3	6/9
Beebe et al., (2011)	RCT, embedded prospective[b], outpatients, United States.	Pedometer[a], total minutes walked	-	4 months	• *n*=97 • 71.1% schizoaffective disorder, 28.9% schizophrenia. • 52.6% male • Mean age (years) 46.9 SD 2.0.	2/4	0/2	3/3	5/9
Gardner – Sood (2015)	Prospective, inpatients, United Kingdom	The International Physical Activity Questionnaire (IPAQ) measured over the last 7-days	The Dietary Instrument for Nutrition Education (DINE) measured over the last 7-days	12 months	• *n*=169 • All first episode psychosis, 20% schizophreniform disorder, 16% schizophrenia, 11.2% manic episode with psychosis, 8.3% major depressive episode with psychotic feature, 5.9% psychotic disorder not otherwise specified, 3.6% schizoaffective disorder depressed, 3.6% schizophrenia, 3% delusional disorder, 1.8% major depressive disorder. 26.6% unknown. • 65% male. • Mean age (years) 29.7.	Physical activity 2/4 Diet 2/4	0/2 0/2	2/3 2/3	4/9 4/9
Jakobsen et al., (2018)	Embedded prospective, primary and secondary care, Denmark	Cardiorespiratory fitness calculated via maximal oxygen uptake VO2	The Dietary Quality Score (DQS)	24 months	• *n*=428 • 88.3% schizophrenia, 10.5% schizoaffective psychosis, 1.2% persistent delusional disorder. 45% male. • 96.5% unemployed. • Mean age (years) 38.6 SD 12.4. • BMI mean 34.2 SD 6.0 • Positive symptoms (SAPS) mean 2.2 SD 1.6 • Negative symptoms (SANS) mean 2.6 SD1.2 • Antidepressant users 43.7%	Physical activity 3/4 Diet 3/4	2/2 2/2	3/3 2/3	8/9 7/9
Nyboe et al., (2016)	Prospective, outpatients, Denmark	The Physical Activity scale (PAS) over the last 7-days	-	12 months	• *n*=101 • All first episode schizophrenia • 67% male. • 3.8% on wages, 61.9% social security 18.5% educational grants, 13.4% sickness benefit, 4.1% unemployment grant, 1% no income. • Mean age (years) 24.9 SD 7.1. • BMI mean 24.9 SD 4.3 • Positive symptoms (SAPS) mean 2.09 SD1.34 • Negative symptoms (SANS) mean 2.06 SD1.12	3/4	2/2	2/3	7/9

[a] *Obtained from author*
[b] *No significant intervention effects. Correlation analysis combined treatment arms.*
BRPS Brief Psychiatric Rating Scale
SANS Scale for Assessment of Negative symptoms
SAPS Scale for Assessment of Positive symptoms

Table 2. Summary of exposures and their association to PA related outcomes across studies

Exposure Variable	Statistically significant association to physical activity related outcome		Not statistically significant association to physical activity related outcome	
	Study	**Direction of association**	**Study**	**Direction of association**
Age (older)	Arbour-Nicitopoulos et al (2017); Beebe et al (2011)	+ +		
Gender (Reference category NR)			Arbour-Nicitopoulos et al (2017); Nyboe et al (2016)	NR NR
Employment (yes)	Jakobsen et al (2018)	+		
Antipsychotic medication dosage (higher)			Jakobsen et al (2018)	-
Duration of illness in years (longer)	Jakobsen et al (2018)	-		
Negative symptoms (higher)	Jakobsen et al (2018); Nyboe et al (2016)	- -		
Positive symptoms (higher)			Jakobsen et al (2018)	-
Social support (higher)			Arbour-Nicitopoulos et al (2017)	+
Friendship (yes)			Jakobsen et al (2018)	+
Functioning (higher)	Jakobsen et al (2018)	+		
Cognition (higher)	Jakobsen et al (2018)	+		
Previous physical activity (higher)			Arbour-Nicitopoulos et al (2017)	+
Physical activity intentions (higher)			Arbour-Nicitopoulos et al (2017); Gardner-Sood (2015)	+ +
Dietary intentions (higher)			Gardner-Sood (2015)	+
BMI (lower)	Arbour-Nicitopoulos et al (2017)	+		
Health Action Process Constructs (higher): **Action planning** **Coping planning** **Maintenance self-efficacy**			Arbour-Nicitopoulos et al (2017)	 + + +
Health risk appraisal constructs (higher): **Manageability of threat** **Perceived personal vulnerability** **Self-efficacy (diet)** **Self-efficacy (physical activity)**			Gardner-Sood (2015)	 + - + +

"NR" not reported
"+" Positive association
"-" Negative association

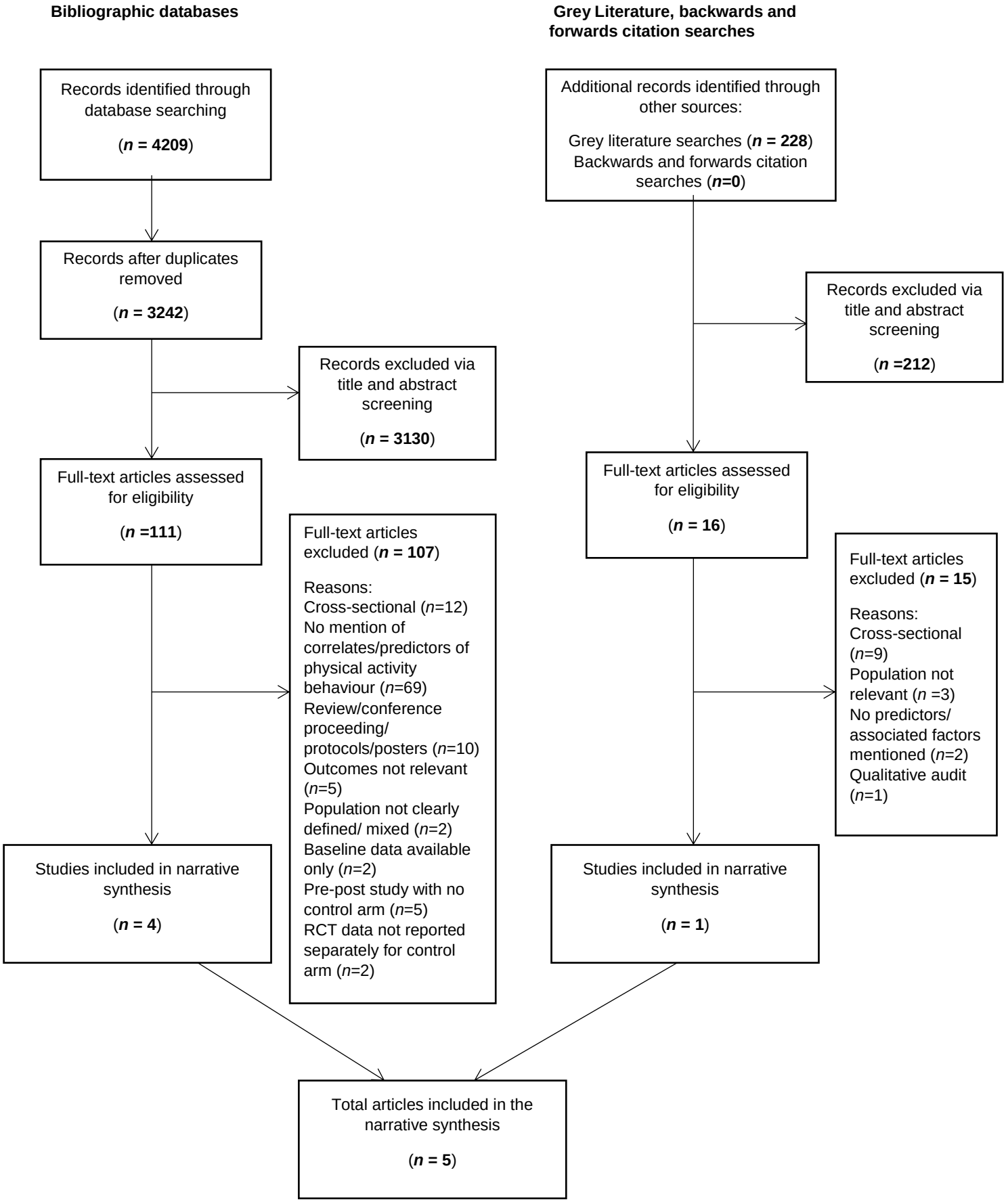

Figure 1. Flow diagram representing stages of identifying articles in physical activity searches.

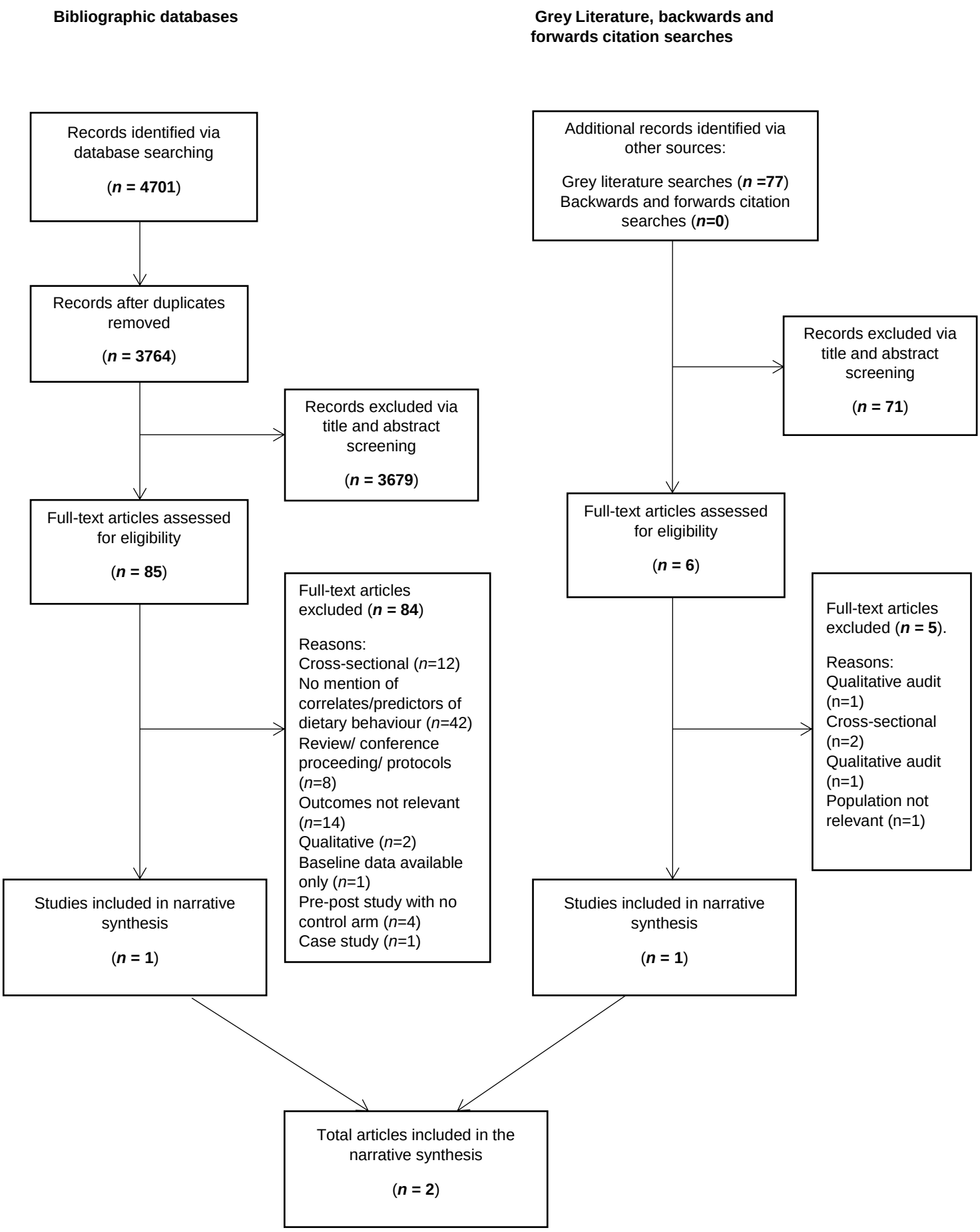

Figure 2. Flow diagram representing stages of identifying articles in diet searches.

Supplementary data

List of non- English articles excluded during title and abstract stages

Physical activity

Study ID	Language	Reference
Aagaard & Andersen (2005)	Danish	Aagaard, J., & Andersen, C. (2005). Overweight and psychiatric disease: Preliminary experiences from a psychoeducative weight reduction program. [Danish]. [Overvaegt og psykisk sygdom: Forelobige erfaringer fra et psykoedukativt vaegtreduktionsprogram.]. Ugeskrift for Laeger, 167(21), 2279-2281.
Calleja et al (2007)	Spanish	Calleja, A. M. G., German, M. A. S., Trincado, M. R., & de Lucas, A. G. (2007). Cognitive behavioral weight-loss program for individuals with psychotic mental diseases. Psicothema, 19(4), 640-645.

Diet

Study ID	Language	Reference
Aagaard & Andersen (2005)	Danish	Aagaard, J., & Andersen, C. (2005). Overweight and psychiatric disease: Preliminary experiences from a psychoeducative weight reduction program. [Danish]. [Overvaegt og psykisk sygdom: Forelobige erfaringer fra et psykoedukativt vaegtreduktionsprogram.]. Ugeskrift for Laeger, 167(21), 2279-2281.
Calleja et al (2007)	Spanish	Calleja, A. M. G., German, M. A. S., Trincado, M. R., & de Lucas, A. G. (2007). Cognitive behavioral weight-loss program for individuals with psychotic mental diseases. Psicothema, 19(4), 640-645.
Nunes et al (2014)	Spanish	Nunes, D., Eskinazi, B., Camboim Rockett, F., Delgado, V. B., & Schweigert Perry, I. D. (2014). Nutritional status, food intake and cardiovascular disease risk in individuals with schizophrenia in southern Brazil: A case-control study. [Spanish]. [Estado nutricional, ingesta alimentaria y riesgo de enfermedad cardiovascular en individuos con esquizofrenia en el sur de Brasil: estudio de casos-controles.]. Revista de Psiquiatria y Salud Mental, 7(2), 72-79.
Provencher et al (2016)	French	Provencher, M., Belanger, M., Shriqui, C., Lachance, I., & Bonneville, S. (2016). Psychoeducation for overweight patients with psychiatric disorders: The Wellness program developed in Quebec. L'Encephale: Revue de psychiatrie clinique biologique et therapeutique, 42(3), 201-207.
Zortea et al (2010)	Portuguese	Zortea, K., Guimaraes, L. R., Gama, C. S., & Belmonte-de-Abreu, P. S. (2010). Nutritional status of patients with schizophrenia who attend the Psychosocial Care Center (CAPS), Hospital de Clinicas de Porto Alegre. [Portuguese]. [Estado nutricional de pacientes com esquizofrenia frequentadores do Centro de Atencao Psicossocial (CAPS) do Hospital de Clinicas de Porto Alegre.]. Jornal Brasileiro de Psiquiatria, 59(2), 126-130.

Example search strategy syntax in MEDLINE for Physical Activity

1. exp "Bipolar and related disorders"/ or exp affective disorders, psychotic/ or exp psychotic disorders/ or exp schizophrenia/

2. exp Schizophrenic Psychology/

3. sever* mental* disorder*.mp.

4. sever* mental* ill*.mp.

5. serious* mental* ill*.mp.

6. serious* mental* disorder*.mp.

7. psychotic.mp.

8. psychos#s.mp.

9. psychotic depress*.mp.

10. persistent delusion* disorder*.mp.

11. schizophren*.mp.

12. schizoaffective disorder*.mp.

13. bipolar*.mp.

14. exp Exercise/

15. exp Exercise Therapy/

16. exp physical fitness/

17. physical* activ*.mp.

18. physical* exercise*.mp.

19. exercise therap*.mp.

20. exercise behavio?r*.mp.

21. physical* inactiv*.mp.

22. physical* fit*.mp.

23. physical* train*.mp.

24. exp Sedentary Lifestyle/

25. (sedentary lifestyle* or sedentary behavio?r*).mp.

26. (lifestyle change* or behavio?r change*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

27. exp Cohort Studies/

28. exp epidemiologic studies/

29. cohort*.mp.

30. longitudinal*.mp.

31. prospective*.mp.

32. retrospective*.mp.

33. follow-up*.mp.

34. exp clinical trial/

35. exp Clinical Studies as Topic/

36. exp Randomized Controlled Trial/

37. exp Randomized Controlled Trials as Topic/

38. exp multicenter study/

39. exp Multicenter Studies as Topic/

40. clinical trial*.mp.

41. random* trial*.mp.

42. controlled trial*.mp.

43. exp meta-analysis/

44. exp Meta-Analysis as Topic/

45. ((comprehensive* or integrative or systematic) and (bibliographic* or review* or literature*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

46. (meta-analy* or meta analy* or meta-regress* or meta regress*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

47. ((research or information or data) and synthes*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

48. or/1-13

49. or/14-26

50. or/27-47

51. 48 and 49 and 50

52. exp Animals/ not Humans/

53. 51 not 52