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How much physical activity do people with schizophrenia engage in? A systematic review, comparative meta-analysis and meta-regression

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ABSTRACT

Objective: Physical activity (PA) improves health outcomes in people with schizophrenia. It is unclear how much PA people with schizophrenia undertake and what influences PA participation. We conducted a meta-analysis to investigate PA levels and predictors in people with schizophrenia.
Method: Major databases were searched from inception till 02/2016 for articles measuring PA (self-report questionnaire (SRQ) or objective measure (e.g. accelerometer)) in people with schizophrenia, including first episode psychosis (FEP). A random effects meta-analysis and meta-regression analysis were conducted.
Results: 35 studies representing 3453 individuals with schizophrenia (40.0 years; 64.0% male) were included. Engagement in light PA was 80.44 min (95% CI 68.32–92.52, n = 2658), 47.1 min moderate-vigorous PA (95% CI 31.5–62.8, n = 559) and 1.05 min (95% CI 0.48–1.62, n = 2533) vigorous PA per day. People with schizophrenia engaged in significantly less moderate (hedges g = −0.45, 95% CI −0.79 to −0.1, p = 0.01) and vigorous PA (g = −0.4, 95% CI −0.60 to −0.18) versus controls. Higher light to moderate, but lower vigorous PA levels were observed in outpatients and in studies utilizing objective measures versus SRQ. 56.6% (95% CI 45.8–66.8, studies = 12) met the recommended 150 min of moderate physical activity per week. Depressive symptoms and older age were associated with less vigorous PA in meta-regression analyses.
Conclusions: Our data confirm that people with schizophrenia engage in significantly less moderate and vigorous PA versus controls. Interventions aiming to increase PA, regardless of intensity are indicated for people with schizophrenia, while specifically increasing moderate-vigorous PA should be a priority given the established health benefits.

1. Introduction

People with schizophrenia experience a premature mortality gap of between 10 and 20 years from the general population (Walker et al., 2015). There is an abundance of literature demonstrating that people with schizophrenia experience high levels of metabolic syndrome (Mitchell et al., 2013; Vancampfort et al., 2015d), type two diabetes (Stubbs et al., 2015b) and cardiovascular disease (Gardner-Sood et al., 2015), which collectively account for over 70% of the premature mortality in this group (Lawrence et al., 2013).

There is promising evidence that physical activity (PA) interventions can improve cardio-metabolic outcomes and improve mental health symptoms in people with schizophrenia (Firth et al., 2015; Rosenbaum et al., 2014). Even in the absence of a change in weight status, PA can result in improvements in cardiorespiratory fitness (Vancampfort et al., 2015c), which is a better predictor of mortality

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than BMI in the general population (Barry et al., 2014). There is also emerging evidence that PA can improve cognition in people with schizophrenia (Kimhy et al., 2016). However, people with psychotic disorders are highly sedentary (Stubbs et al., 2015a, 2016) and experience a range of barriers to PA such as negative symptoms, pain and the side-effects of medication (Soundy et al., 2014a; Vancampfort et al., 2011, 2012). Consequently, it might be hypothesized that many people with schizophrenia do not meet recommended PA guidelines such as accruing 150 min of moderate-vigorous PA per week (Vancampfort, 2012). It remains unclear exactly how much PA people with schizophrenia engage in, and at what intensity (i.e. light, moderate and vigorous). Moreover, the moderators of PA participation are not fully elucidated.

Given that physical activity is a modifiable risk factor for cardiovascular disease and can simultaneously improve symptoms, understanding physical activity levels and predictors among people with schizophrenia is of high clinical significance. To our knowledge, only one preliminary review has considered PA levels (Soundy et al., 2013) in people with schizophrenia. The authors (Soundy et al., 2013) focused only on outpatients and found that across three studies, people with schizophrenia engage in less light, moderate and vigorous physical activities compared to controls ($p < 0.01$). Since this review was published, there has been a rapid increase in the number of published papers on PA and schizophrenia, however a number of pertinent questions remain unanswered. For instance, it remains unclear how much time people with schizophrenia engage in each category of PA (light, moderate and vigorous) and which factors (e.g. negative symptoms, depressive symptoms, cognitive symptoms, mean age) influence PA. Understanding this has important implications for the successful delivery of interventions aiming to increase PA participation in practice. Moreover, some studies have utilized self-report questionnaires (SRQ) to measure PA and others have used objective measures such as accelerometers (the gold standard; (Soundy et al., 2013, 2014b)). There are concerns that SRQ overestimate PA and research is required to investigate if SRQ report different levels of physical activity compared to objective measurements (Soundy et al., 2014b). Finally, it remains unclear if people with schizophrenia are less physically active than controls and exactly what this difference (if any) is.

Given the aforementioned, we set out to conduct a systematic review with the following aims 1) establish the mean time of light, moderate and vigorous PA in people with schizophrenia per day. 2) Investigate differences in PA between SRQ and objective measures. 3) Investigate moderators of each category of PA in meta-regression analyses. 4) Investigate differences in PA in people with schizophrenia versus controls.

2. Method

This systematic review adhered to the MOOSE guidelines (Stroup et al., 2000) and PRISMA statement (Moher et al., 2009).

2.1. Inclusion criteria

We included studies that: (a) included adult participants with a diagnosis of schizophrenia spectrum disorder (including first episode psychosis) according to established criteria (e.g., DSM-IV, (American Psychiatric Association, 2000) or ICD-10, (World Health Organisation, 1993)). Studies with mixed samples of mental illnesses (e.g. psychotic disorders) were only eligible if >80% of the sample had schizophrenia and/ or reported the data specifically for those with schizophrenia. (b) Reported the amount of time of PA participation including light, moderate, moderate-vigorous, vigorous and total PA per day with either a SRQ (e.g. IPAQ (Craig et al., 2003)) or objective measure (e.g. accelerometer). Physical activity was defined as any intervention that uses bodily movement produced by skeletal muscles and which requires energy expenditure (Caspersen et al., 1985). Studies measuring exercise only, defined as planned, structured, repetitive and purposive activity seeking to improve or maintain physical fitness or health was an objective, were not included. We also included articles that reported the proportion of people with schizophrenia meeting the 150 min per week of moderate-vigorous PA (c) and were interventional (RCTs, CCTs) and observational (prospective or cross-sectional) studies conducted in any setting (inpatients or outpatients). (d) They were published in an international peer-reviewed journal or a published dissertation in English language.

2.2. Information sources and searches

Two independent authors searched MEDLINE, PsycINFO, and EMBASE from inception till 10th February 2016 (schizophrenia or psychosis or schiz*) AND (physical activity or exercise or walking or accelerometer or accelero*). In addition, reference lists of all eligible articles and related systematic reviews were screened to identify potentially eligible articles (Soundy et al., 2013).

2.3. Study selection

After removal of duplicates, one reviewer screened titles and abstracts of all potentially eligible articles. A second author confirmed included studies and a final list of included studies was developed.

2.4. Outcomes

The primary outcome was the mean time (minutes) per day of light, moderate, and vigorous PA per day that people with schizophrenia engaged in. Physical activity categories are standardized according to the metabolic equivalents (MET), which illustrates the energy expenditure categories: light (1.5–3 METs), moderate (3–6 METs), and vigorous (>6 METs) (Soundy et al., 2013). We also collected data on physical activity among healthy controls where possible.

2.5. Data extraction

Two authors (JF, DV) extracted data using a predetermined data extraction form. The data extracted included first author, country, setting, population, type of the study (prospective, controlled or randomized controlled trial), number of studies and participants included in the article (including mean age, % female, total, negative and positive symptoms and depressive symptoms), type and definition of physical activity (objective or self-report, reference period), and results.

2.6. Meta-analysis

Due to the anticipated heterogeneity across studies, we conducted a random effects meta-analysis with Comprehensive Meta-analysis software (CMA, Version 3). The meta-analysis was conducted in the following sequence. First, we calculated the mean amount of time spent in low, moderate, moderate-vigorous and vigorous PA per day (minutes per day) among people with schizophrenia together with the 95% confidence intervals (CI). Second, we calculated the subgroup differences in each PA category according to the measurement (self-report versus objective measurement), diagnosis (FEP, schizophrenia spectrum and mixed psychotic disorder). Third, we investigated potential moderators of PA participation in people with psychosis with Meta regression analyses. The potential moderators of interest were mean age, % of males, sedentary behavior measurement (objective versus self-report), illness duration, BMI, depressive symptoms and psychiatric symptoms, defined as the symptoms of psychotic disease severity measured with a validated scale including total negative and positive symptoms. Fourth, we conducted a comparative meta-analysis investigating differences in each PA category among people with schizophrenia and healthy

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controls calculating hedges g and the 95% CI as the effect size. In addition, we calculated the mean difference in minutes per day together with the 95% CI. Finally, we calculated the proportion of people with schizophrenia meeting the recommended PA guidelines together with 95% CI. Heterogeneity was assessed with the I^2 statistics for each analysis (Higgins et al., 2003). Publication bias was assessed and adjusted for with a trim and fill adjusted analysis (Duval and Tweedie, 2000) to remove the most extreme small studies from the positive side of the funnel plot, and recalculated the effect size at each iteration, until the funnel plot was symmetric about the (new) effect size.

3. Results

3.1. Study selection

The initial electronic database searches identified 2745 articles (excluding duplicates) which were considered at the title and abstract level. 234 full texts were reviewed and 199 were excluded with reasons (see Fig. 1), with 35 unique studies meeting the eligibility criteria (Arbour-Nicitopoulos et al., 2014; Arbour-Nicitopoulos et al., 2010; Attux et al., 2013; Baker et al., 2014; Beebe et al., 2011; Bredin et al., 2013; Brunero and Lamont, 2010; Curtis et al., 2015; Faulkner et al., 2006; Firth et al., 2016; Gardner-Sood et al., 2015; Gomes et al., 2014, 2015; Gorczynski et al., 2014; Janney, 2012; Janney et al., 2015; Keller-Varady et al., 2015; Kimhy et al., 2014; Leutwyler et al., 2013, 2015; Lindamer et al., 2008; Lovell et al., 2014; Masa-Font et al., 2015; McCreadie, 2003; McKibbin et al., 2006; McLeod et al., 2009; Morgan et al., 2014; Ostermann et al., 2012; Scheewe et al., 2013; Snethen et al., 2014; Vancampfort et al., 2013a, 2013c, 2015a; Vreeland et al., 2003; Wang et al., 2012) Full details of the search results are summarized in Fig. 1.

3.2. Details of included studies and participants' characteristics

Full details of the included studies and participants are presented in Table 1. Briefly, there were 3453 individuals with schizophrenia with a mean age of 40.0 years (range 17–60.3 years), 64.0% male (range 0–100%) and mean illness duration of 14.4 years (range 1.9–26.2 years). The mean BMI of participants was 30.1 (range 23.5–38.7) with the mean proportion of 94% (19.5–100%) taking antipsychotic medication (details, where available, in Table 1). Two studies recruited people with FEP (Curtis et al., 2015; Firth et al., 2016), the majority included people with schizophrenia spectrum (full details in Table 1). Overall, 12 studies assessed physical activity using an objective measure (Beebe et al., 2011; Gomes et al., 2014, 2015; Gorczynski et al., 2014; Kimhy et al., 2014; Leutwyler et al., 2013, 2015; McCreadie, 2003; Scheewe et al., 2013; Snethen et al., 2014; Wang et al., 2012), one utilized an objective and subjective measure (Lindamer et al., 2008), while the remaining studies used a SRQ, primarily the IPAQ SF (Table 1). Light, moderate, moderate-vigorous and vigorous physical activity was captured by 22 (n = 2658), 22 (n = 2563), 16 (n = 559) and 21 (n = 2533) study estimates respectively.

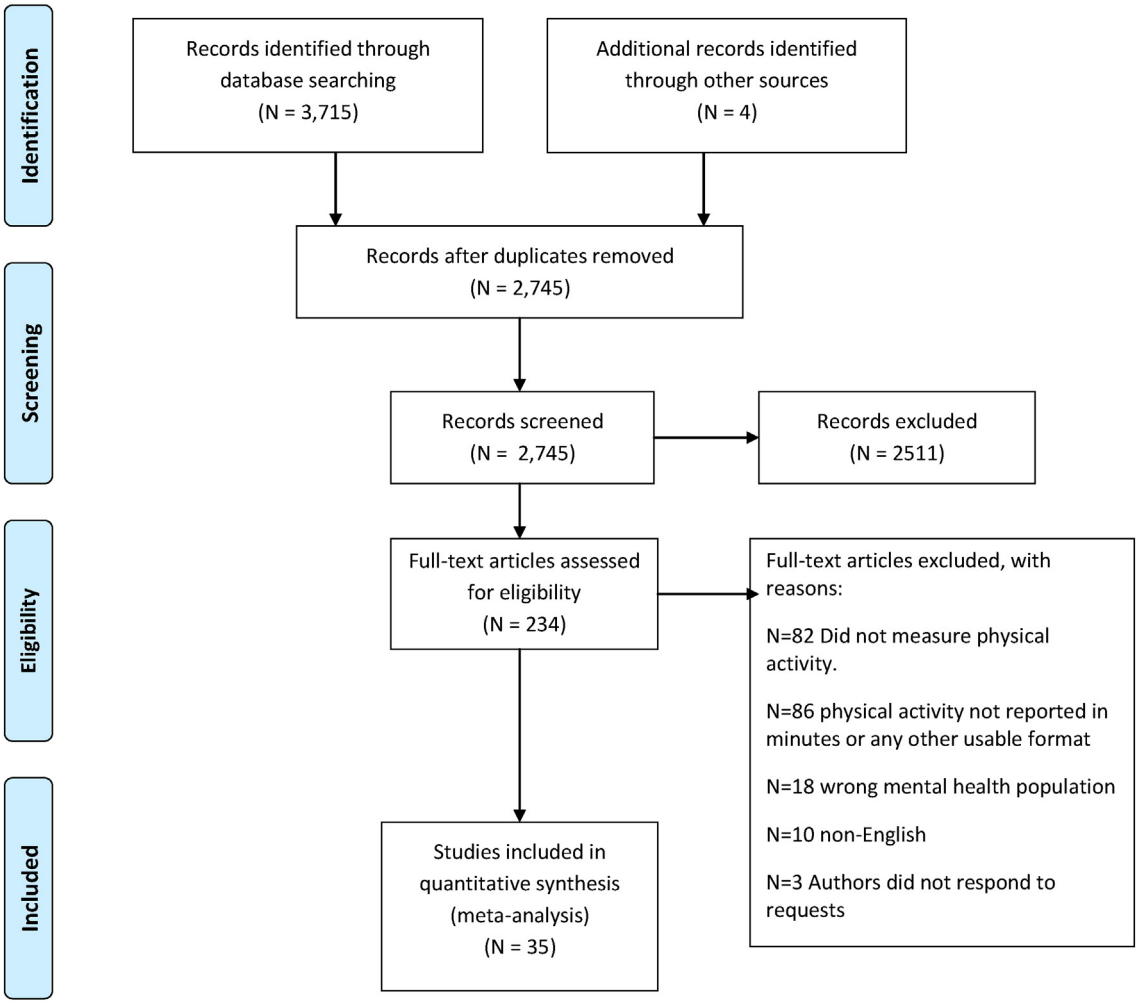

Fig. 1. Prisma flow diagram.

Table 1
Details of included studies, participants and physical activity measurement.

Author	Study setting and location	Physical activity measurement	Details of PA and reference period	Schizophrenia participants (N = only participants with valid physical activity data)	Control group
Arbour-Nicitopoulos (2010)	Outpatient, Canada, Cross sectional study	SRQ	IPAQ-SF, last 7 day recall	N = 92 schizophrenia spectrum, mean age 37.5 years, 65.2% male, 13.5 illness duration, BMI 29.1. 100% taking antipsychotics.	No healthy control group
Arbour-Nicitopoulos (2014)	Outpatient, Canada, pre and post study	SRQ	IPAQ-SF, last 7 day recall	N = 26 schizophrenia spectrum, mean age 41.5 years, 61.5% males and mean BMI 32.4. BPRS 33.4.	No healthy control group
Attux et al. (2013)	Outpatient, Brazil, pre and poststudy	SRQ	IPAQ-SF, last 7 day recall	*Control group*: N = 66 psychosis, 38.3 years, 61% male, 13.1 years illness duration and BMI 29.9, 99% taking antipsychotics. PANNS total 61.6, negative 12.1 & positive 18.7. 2.8 Calgary depression scale. *Intervention* group: N = 60 psychosis, 36.2 years, 62% male, 14.3 years illness duration, BMI 29.1. PANSS total 56.4, negative 12.3, positive 16.2. Calgary depression scale 2.6	No healthy control group
Baker et al. (2014)	Outpatient, Australia, pre and post study	SRQ	IPAQ-SF, last 7 day recall	N = 17 psychosis, 33.9 years, 53% male, 12.4 years illness duration. 100% taking antipsychotics.	No healthy control group
Beebe et al. (2011)	Outpatient, US, RCT	OBJ	Pedometer, minutes walked over past month	N = 49 schizophrenia, 57% male 80% taking antipsychotics.	No healthy control group
Bredin et al. (2013)	Community, Canada, pre and poststudy	SRQ	Godin Shephard Leisure Time Questionnaire average weekly PA	N = 13 schizophrenia, 30.9 years, 53.8% male, BMI 29, 100% taking antipsychotics. PANSS total 99.2.	No healthy control group
Brunero and Lamont (2010)	Inpatient, Netherlands, cross sectional	SRQ	Questions if completed more or <150 min PA in last week	N = 99 schizophrenia, 38.5 years, 62% male, BMI 30.75, 100% taking antipsychotics	No healthy control group
Curtis et al. (2015)	Outpatient, Aus, prospective study	SRQ	IPAQ-SF, last 7 day recall	N = 15 FEP, 20 years, 44% male BMI 23.5, 100% taking antipsychotics.	No healthy control group
Faulkner et al. (2006)	Outpatient, Canada, pre and poststudy	SRQ	IPAQ-SF, last 7 day recall	N = 35 schizophrenia, 39.66 years, 63% male, BMI 30.56, 100% taking antipsychotics.	No healthy control group
Firth et al. (2016)	Community, UK, pre and post-test study	SRQ	IPAQ-SF, last 7 day recall	N = 29 FEP, 25.8 years, 81% male, 1.9 illness duration, BMI 30.2, 100% taking antipsychotics. PANSS total 78.6, negative18.8, positive 19.2 and 22.3 BDI.	No healthy control group
Gardner-Sood et al. (2015)	Community, UK, RCT	SRQ	IPAQ-SF, last 7 day recall	N = 299 schizophrenia, 43.4 years, 69.0% males, 15.7 years illness duration, PANSS total 51.2, positive 11.8, negative 12.9	No healthy control group
Gomes et al. (2014)	Community, Portugal, quasi experimental	OBJ	GTX3, 7 consecutive days	*Control* N = 11 schizophrenia, 40 years, 84% male, BMI 27.5, 100% taking antipsychotics. *Intervention* N = 8 schizophrenia, 39 years, 84% male, BMI 29, 100% taking antipsychotics.	No healthy control group
Gomes et al. (2015)	Community, Portugal, cross sectional	OBJ	GTX3, 7 consecutive days	N = 32 schizophrenia, 41.16 years, 71.9% male, BMI 29.6	N = 32, 38.56 years, 68.8% male, BMI 27.66
Gorczynski et al. (2014)	Community, Canada, cross sectional	OBJ	Uni-axial accelerometer (ActiGraph), 7 consecutive days	N = 4 schizophrenia, 29.5 years, 50% male, 11.8 years illness duration, BMI 38.7, 100% taking antipsychotics.	No healthy control group
Janney et al. (2015)	Community, US, cross sectional	SRQ	Modified Activity Questionnaire, last 7 days	N = 252 schizophrenia, 35.7% male, 80% taking antipsychotics	No healthy control group
Janney et al. (2015)	Outpatient, US, cross sectional	OBJ	ActiGraph, 7 consecutive days	N = 46 schizophrenia, 45.6 years, 58% male, 15.5 years illness duration, BMI 38, 100% taking antipsychotics. 58.8 PANSS total	No healthy control group
Keller-Varady et al. (2015)	Germany, pre and poststudy	SRQ	Questions if completed more or <150 min PA in last week	*Intervention* N = 22 schizophrenia, 37.3 years, 73% male, 10.2 years illness duration, BMI 29.4, 100% taking antipsychotics. *Control* N = 19 schizophrenia, 35.8 years, 71% male, 11.7 years illness duration, BMI 27.4, 80% taking antipsychotics.	N = 32, 38.56 years, 68.8% male, BMI 27.66
Kimhy et al. (2014)	Outpatient, US, cross sectional	OBJ	ActiGraph for 36 h	N = 32 schizophrenia, 37.3 years, 63% male, BMI 32.1, 100% taking antipsychotics. 7.59 BDI	No healthy control group
Leutwyler et al. (2015)	Community and inpatients, US, cross sectional	OBJ	Sensewear armband, 5 consecutive days	N = 30 schizophrenia, 60 years, 60% male, BMI 30.3, 90% taking antipsychotic medication. PANSS total 75, positive 16 and negative scale 13.5	No healthy control group
Leutwyler et al. (2015)	Community and inpatients, US, cross sectional	OBJ	SenseWear Pro armband, 7 consecutive days	N = 15 schizophrenia, 60.3 years, 80% male.	No healthy control group
Lindamer et al. (2008)	Community, US, cross sectional	OBJ and SRQ	ActiGraph, 3 of last 7 days. Yale Physical Activity Scale, typical week in last month.	N = 16 objective data and N = 54 SRQ data. 50.7 years, 59.3% male, BMI 30.5	N = 27 SRQ data and N = 6 OBJ data. 52.2 years, 59.3% male, BMI 27.8
Lovell et al. (2014)	Community, UK, RCT	SRQ	IPAQ-SF, last 7 day recall	N = 102 schizophrenia, 25.7 years, BMI 32.4, 100% taking antipsychotic.	No healthy control group
Masa-Font et al.	Outpatient,	SRQ	IPAQ-SF, last 7 day	N = 223 schizophrenia, 45 years, 61.4% male, BMI 32.2, 100%	No healthy control group

Table 1 (*continued*)

Author	Study setting and location	Physical activity measurement	Details of PA and reference period	Schizophrenia participants (N = only participants with valid physical activity data)	Control group
(2015)	Spain, RCT		recall	taking antipsychotics.	
McCreadie (2003)	Community, UK, cross sectional	SRQ	Scottish Physical Activity Questionnaire, last 7 days.	N = 72 males, 43 years 100% males, illness duration 21 years. N = 29 females, 50 years, illness duration 21 years	No healthy control group
McKibbin et al. (2006)	Community, US, cross sectional	OBJ	Accelerometer, 3 consecutive days	*Control* N = 29 schizophrenia, 54.8 years, 62.1%, illness duration 25.5 years, BMI 32.9, 100% taking antipsychotics. *Intervention* N = 28, 53.1 years, 67.9% male, illness duration 26.2 years, BMI 33.6	No healthy control group
McLeod et al. (2009)	Outpatient, Aus, cross sectional	SRQ	Active Australia survey, last 7 days.	N = 125 schizophrenia, 40.3 years, 64.8%, BMI 28.92	No healthy control group
Morgan et al. (2014)	Community, Aus, prospective	SRQ	IPAQ-SF, last 7 day recall	N 1134 schizophrenia, 39 years, 66% male, illness duration 15.25 years, 91% taking antipsychotic medication.	No healthy control group
Ostermann et al. (2012)	Inpatient, Germany, cross sectional	SRQ	IPAQ-SF, last 7 day recall	N = 23 schizophrenia, 28.4 years, 69.6% males, illness duration 4.1 years, BMI 24. 82.6% taking antipsychotics, PANSS 74 total symptoms.	N = 23, 28.2 years, 73.9% male, BMI 23.6
Scheewe et al. (2013)	Netherlands, cross sectional	OBJ	Sensewear armband, 4 consecutive days	N = 62 schizophrenia, 29.6 years, 73% male, illness duration 6.6 years, BMI 26.3. 100% taking antipsychotics. PANSS total 62.6, positive 15.52and negative scale 17.46	N = 52, 29.3 years, 65.5% male, BMI 23.9.
Snethen et al. (2014)	Outpatient, US, cross sectional	OBJ	Uni-axial accelerometer (ActiGraph), 8 consecutive days	N = 30 schizophrenia, 50.6 years, 89.3% male, BMI 32.18	No healthy control group
Vancampfort et al. (2013b)	In and outpatients, Belgium, cross sectional	SRQ	IPAQ-SF, last 7 day recall	N = 138 schizophrenia, 41.2 years, 67% male, BMI 27.7	No healthy control group
Vancampfort et al. (2013c)	In and outpatients, Belgium, cross sectional	SRQ	IPAQ-SF, last 7 day recall	N = 80 schizophrenia, 36.8 years, 68.8% male, illness duration 12.8 years, BMI 26.3. 99% taking antipsychotics.	N = 40, 37.1 years, 68% male, BMI 25.7
Vancampfort et al. (2015b)	In and outpatients, Belgium, cross sectional	SRQ	IPAQ-SF, last 7 day recall	N = 50 schizophrenia, 33.8 years, 68% male, 12.4 illness duration, BMI 25.7.	No healthy control group
Vreeland 2003 Intervention	Community, US, CCT	SRQ	Minutes exercise per week.	N = 31 schizophrenia, 42.6 years, 61% male, BMI 34.3, 100% taking antipsychotics.	No healthy control group
Wang et al. (2012)	US, cross sectional	OBJ	Uniaxial accelerometer (Actigraph), 4 consecutive days	N = 48 schizophrenia, 72 years, 21.5% male, 100% taking antipsychotics.	No healthy control group

Key: SRQ = self-report questionnaire, OBM = objective measurement, PA = physical activity, BMI = body mass index, IPAQ-SF = International Physical Activity Questionnaire Short Form, US = United States, Aus = Australia, UK = United Kingdom, PANSS = positive and negative symptoms scale, FEP = first episode psychosis, BDI Beck Depression Inventory.

4. Meta-analysis results

Full details of all meta-analysis results, including heterogeneity and publication bias data are presented in Table 2. Key results are highlighted below.

4.1. Meta-analysis of daily amount of light physical activity

Across all 22 studies, people with schizophrenia engaged in 80.44 min (95% CI 68.3–92.5, n = 2658) light physical activity per day. The trim and fill analysis demonstrated a slightly increased mean amount of light physical activity (88.91 min, Table 2).

4.2. Subgroup analyses

4.2.1. Differences in light physical activity in self-report and objective measurement

Significantly ($p < 0.001$) higher levels of light physical activity were reported with objective measures versus SRQ. The difference between objective (192.1 min per day, 95% CI 136.2–247.9, n = 235) and SRQ (24.8 min per day, 95% CI 16.5–33.2, n = 2333) was larger after the trim and fill analysis.

4.2.2. Primary psychiatric diagnosis

Full details are presented in Table 2. Briefly, data from 17 studies (n = 2294) illustrated that people with schizophrenia engaged in higher levels of light physical activity (98.58 min per day, 95% CI 83.59–113.56) than did other diagnostic groups.

4.2.3. Study setting

Higher levels of light physical activity were observed in community (n = 1223, 83.33 min per day, 95% CI 47.6–119.1) and outpatient settings (studies = 14, n = 1060, 99.3 min per day, 95% CI 80.1–118.5) than in inpatient settings.

4.2.4. Meta-regression of light physical activity

Meta-regression analysis (Table 3) illustrated that increasing age ($\beta = 8.4$, $p = 0.0009$, $R^2 = 0.35$), a higher percentage of males ($\beta = 5.02$, $p = 0.0022$, $R^2 = 0.31$) and objective measures moderated higher light PA.

4.3. Meta-analysis of daily amount of moderate physical activity

Across 22 studies, after the Duval and Tweedie trim and fill adjustment the pooled mean of moderate physical activity per day was 16.2 min (95% CI 11.4–21.1, n = 2563).

4.3.1. Differences in moderate physical activity in self-report and objective measurement

Significantly higher levels of moderate physical activity (42.2 min per day, 95% CI 34.3–50.1, n = 142) were reported in objective measures versus self-report.

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Table 2
Meta-analysis results of sedentary behaviour among people with psychosis.

Analysis	Number of study estimates	Number of participants	Meta-analysis			Between group p value	Trim and fill effect size (95% CI) [adjusted studies]	I^2
Main analysis			Min per day	95% CI				
Light physical activity								
Mean light PA per day	22	2568	80.44	68.32	92.52		88.91 (69.0–108.7) [1]	99
PA measurement						**<0.001**		
Objective PA	7	235	188.16	173.44	202.88		192.1 (136.2–247.9) [1]	97
SRQ	15	2333	33.30	25.17	41.43		24.8 (16.5–33.2) [5]	90
Primary diagnosis						**<0.001**		
First episode psychosis	2	131	42.2	21.1	445.7		N/A	76
Schizophrenia spectrum	17	2294	98.58	83.59	113.56		78.8 (63.8–93.8) [2]	98
Mixed psychosis	3	143	33.73	0.254	67.72		Unchanged	0
Study setting						**0.02**		
Community	4	1223	83.33	47.61	119.05		107.3 (11.9–202.7) [1]	98
Inpatient	1	66	49.5	0.279	126.99		N/A	0
Outpatient	14	1060	99.26	80.06	118.46		Unchanged	98
Mixed	3	219	23.97	−16.018	63.96		Unchanged	84
Moderate physical activity								
Mean moderate PA per day	22	2563	25.80	21.03	30.65		16.2 (11.4–21.1) [7]	94
PA measurement						**<0.001**		
Objective PA	7	142	42.22	34.34	50.11		35.6 (26.8–43.8) [3]	56
SRQ	15	2421	18.13	14.94	23.31		Unchanged	93
Primary diagnosis						**=0.04**		
First episode psychosis	2	131	9.56	0.503	24.16		Unchanged	81
Schizophrenia spectrum	17	2306	26.02	20.70	31.34		16.8 (11.2–22.3) [5]	95
Mixed psychosis	2	126	35.97	17.31	54.63		N/A	0
Study setting						**<0.001**		
Community	4	1281	13.69	3.42	23.96		6.42 (0.09–12.9) [2]	88
Inpatient	1	23	12.96	0.761	33.41		N/A	0
Outpatient	12	884	28.47	21.90	35.04		25.0 (16.5–33.4) [1]	97
Mixed	5	375	21.48	11.70	31.26		Unchanged	90
Vigorous physical activity								
Mean vigorous PA per day	21	2533	2.56	2.01	3.11		1.05 (0.48–1.62) [10]	94
PA measurement						**<0.001**		
Objective PA	6	112	0.412	0.025	0.849		0.17 (0.005–0.41) [3]	80
SRQ	15	2421	4.683	4.016	5.349		4.51 (2.80–6.22) [4]	82
Primary diagnosis						**<0.001**		
First episode psychosis	2	131	3.796	1.723	5.868		Unchanged	92
Schizophrenia spectrum	17	2276	2.199	1.657	2.741		0.91 (0.37–1.46) [7]	94
Mixed psychosis	2	126	11.568	6.315	16.821		N/A	0
Study setting						**=0.002**		
Community	4	1281	5.12	3.512	6.742		Unchanged	89
Inpatient	1	23	9.4	4.04	14.75		N/A	0
Outpatient	10	853	2.04	1.150	2.93		1.15 (0.33–1.98) [4]	88
Mixed	5	314	2.15	1.00	3.30		Unchanged	93
Unclear	1	62	10.5	5.01	15.98		N/A	0
Moderate-vigorous physical activity								
Mean vigorous PA per day	16	559	36.53	27.55	45.52		47.1 (31.5–62.8) [4]	96
PA measurement						0.74		
Objective PA	9	284	37.79	25.90	49.68		Unchanged	90
SRQ	7	275	34.84	21.45	48.24		49.8 (20.2–78.7)) [2]	97
Primary diagnosis						**0.008**		
First episode psychosis	2	44	6.42	0.175	30.39		N/A	0
Schizophrenia spectrum	14	515	41.16	31.68	50.65		50.3 (32.9–67.0) [3]	96
Study setting						**0.008**		
Community	4	99	17.57	0.273	37.87		14.8 (5.91–23.8) [1]	89
Outpatient	8	200	39.37	24.52	54.22		Unchanged	94
Mixed	2	130	27.85	0.80	56.50		N/A	98
Unclear	2	130	78.88	49.29	108.49		N/A	99

Bold = statistically significant result.

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Table 3
Meta regression of moderators of physical activity in schizophrenia.

Moderator	Number of study estimates	β	95% CI		p value	R^2
Light physical activity						
Mean age	20	8.3654	3.4203	13.3104	**0.0009**	0.35
% males	21	5.0179	1.8032	8.2327	**0.0022**	0.31
Illness duration	10	2.0452	−3.345	7.4354	0.4571	0.06
BMI	17	9.1653	−5.2454	23.5761	0.2126	0.09
% taking antipsychotic medication	16	0.9972	−0.6467	2.6411	0.2345	0.08
Total psychiatric symptoms	6	−0.1754	−1.6393	1.2885	0.8144	0.01
Positive symptoms	6	13.4148	−2.4846	29.3142	0.0982	0.32
Negative symptoms	6	10.207	−7.5563	27.9703	0.2601	0.10
Depressive symptoms	6	−0.6065	−1.9334	0.7204	0.3703	0.18
Self-report v objective measure (SRQ as reference)	22	171.0681	134.1401	207.9962	<**0.001**	0.80
Moderate physical activity						
Mean age	21	0.8021	−0.2345	1.8387	0.1294	0.11
% males	21	0.7922	−0.1594	1.7438	0.1027	0.14
Illness duration	8	−0.7569	−4.8082	3.2943	0.7142	0.01
BMI	18	−0.392	−5.2285	4.4445	0.8738	0
% taking antipsychotic medication	16	0.3385	−0.2827	0.9597	0.2855	0.07
Total psychiatric symptoms	7	0.2859	−0.7253	1.2971	0.5795	0.04
Positive symptoms	8	2.8037	−2.7203	8.3277	0.3199	0.11
Negative symptoms	8	2.4568	−3.3291	8.2426	0.4053	0.09
Depressive symptoms	7	−1.4013	−3.0586	0.2559	0.0975	0.41
Self-report v objective measure (SRQ as reference)	22	23.3737	5.3933	41.3541	**0.0108**	0.24
Vigorous physical activity						
Mean age	20	−0.1738	−0.3259	−0.0216	**0.0252**	0.21
% males	19	−0.0805	−0.2192	0.0582	0.2555	0.08
Illness duration	9	0.0646	−0.3994	0.5285	0.7849	0.02
BMI	17	−0.147	−0.9264	0.6324	0.7117	0.01
% taking antipsychotic medication	15	−0.0446	−0.0379	0.1271	0.2894	0.09
Total psychiatric symptoms	7	0.0067	−0.1206	0.134	0.9177	0
Positive symptoms	7	−0.201	−0.9395	0.5374	0.5936	0
Negative symptoms	7	0.408	−0.3667	1.1828	0.302	0.09
Depressive symptoms	7	−0.4911	−0.9056	−0.0766	**0.0202**	0.48
Self-report v objective measure (SRQ as reference)	22	4.8836	2.1192	7.6481	**0.0005**	0.48
Moderate-vigorous physical activity						
Mean age	16	−0.0993	−1.6806	1.482	0.902	0
% males	16	0.7171	−0.5331	1.9673	0.2609	0.08
Illness duration	8	−1.2662	−4.4097	1.8773	0.4298	0.07
BMI	15	−0.9334	−5.3371	3.4703	0.6778	0.01
% taking antipsychotic medication	13	4.906	−5.5606	15.3725	0.3583	0.06
Total psychiatric symptoms	5	−0.475	−3.1042	2.1542	0.7233	0.03
Positive symptoms	5	1.1502	−7.9344	10.2348	0.804	0.01
Negative symptoms	5	2.658	−6.869	12.1849	0.5845	0.06
Depressive symptoms	4	−3.4294	−7.2614	0.4027	0.0794	0.45
Self-report v objective measure (SRQ as reference)	16	1.9545	−28.5001	32.4092	0.8999	0

4.3.2. Primary psychiatric diagnosis

Significantly higher levels of moderate physical activity were seen in schizophrenia spectrum (Table 2) compared to FEP and those with mixed psychotic disorder.

4.3.3. Study setting

Significantly higher moderate physical activity levels were observed in outpatient (n = 884, 28.5 min per day, 95% CI 21.9–35.04) versus other settings.

4.3.4. Meta-regression of moderate physical activity

Only objective measurements moderated higher levels of moderate physical activity ($\beta = 23.4$, $p = 0.01$, $R^2 = 0.24$).

4.4. Meta-analysis of daily amount of vigorous physical activity

After adjustment for Duval and Tweedie's trim and fill, the meta-analysis demonstrated people with schizophrenia spend 1.05 min per day engaging in vigorous PA (95% CI 0.5–1.6, n = 2553).

4.4.1. Differences in self-report and objective measures of vigorous physical activity

Significantly ($p < 0.001$) higher levels of vigorous PA were reported in SRQ measures (4.51 min, 95% CI 2.8–6.2, n = 2421) versus objective measures (0.2, 95% CI 0.005–0.41, n = 112).

4.4.2. Primary psychiatric diagnosis

Higher levels of vigorous PA were observed in those with psychosis versus schizophrenia spectrum only (Table 2).

4.4.3. Study setting

Higher levels of vigorous PA were reported in one inpatient study versus other settings (Table 2).

4.4.4. Meta-regression of vigorous physical activity

Older people ($\beta = -0.17$, $p = 0.03$, $R^2 = 0.21$) and participants with higher depressive symptoms ($\beta = -0.49$, 0.02, $R^2 = 0.48$) engaged in less vigorous PA. SRQ also moderated a high level of vigorous PA (Table 3).

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4.5. Meta-analysis of daily amount of moderate-vigorous physical activity

The mean adjusted amount of moderate-vigorous PA was 47.1 min per day (95% CI 31.5–62.8, n = 559).

4.5.1. Difference in self-report and objective measurement of physical activity

No difference was observed (Table 2).

4.5.2. Primary psychiatric diagnosis

People with schizophrenia engaged in more moderate-vigorous PA (41.2, 95% CI 31.7–50.7, n = 515) than FEP participants (6.4, 95% CI 0.2–30.4, n = 44) although restricted to two studies using SRQ.

4.5.3. Study setting

Higher levels of moderate-vigorous PA were seen in outpatient compared to inpatient settings.

4.5.4. Meta-regression of moderate-vigorous physical activity

No significant moderators were identified (see Table 3).

4.6. What proportion of people with schizophrenia meet recommended physical activity targets?

Across 12 studies and 646 people with schizophrenia, 56.6% (95% CI 45.8–66.8, I2 = 81%) met the recommended 150 min of moderate physical activity per week. The proportion of people meeting the targets were similar when assessed via objective measures (54.2%, 95% CI 24.5–79.8, studies = 2) or SRQ (56.9%, 95% CI 45.1–68.0, studies 10). People in the community (35.2%, 95% CI 18.8–56.1, studies = 3) and outpatient settings (41.5%, 95% CI 29.2–54.9%, studies = 3) were less likely to meet PA guidelines compared to mixed (69.5%, 95% CI 58.0–79.0, studies = 3), inpatient (51.5%, 95% CI 31.7–70.7, studies = 1) and unclear settings (81.2%, 95% CI 63.1–91.6, studies = 3).

4.7. Differences in physical activity in people with schizophrenia and controls

The comparative meta-analysis results are summarized in Table 4. No significant difference was observed in light PA between people with schizophrenia (n = 150) and controls (n = 101). People with schizophrenia (n = 213) engaged in significantly less moderate PA (hedges g = −0.45, 95% CI −0.79 to −0.1, p = 0.01) versus controls (n = 156) equating to a mean difference of −14.2 min (95% CI −28.0 to-0.16). People with schizophrenia also engaged in significantly less vigorous PA (g = −0.39, 95% CI −0.60 to −0.18) equating to a mean difference of −3.42 min (95% CI −6.15 to −0.59).

5. Discussion

The current study is, to our knowledge, the first to determine PA levels and predictors in people with schizophrenia. We found that people with schizophrenia spend almost 90 min participating in light intensity PA and >45 min in moderate to vigorous PA per day. More than half of the people with schizophrenia included in the present meta-analysis met the recommended 150 min of at least moderate PA per week. Nonetheless, although these data are promising, our meta-analysis also shows that people with schizophrenia still engage in significantly less moderate and vigorous PA than healthy controls.

The observation that there was no difference in level of light PA between people with schizophrenia and controls might be due to the fact that walking is the primary mode of transportation for most people with schizophrenia (Vancampfort et al., 2013b). Higher levels of light PA in community and outpatient settings seem to confirm this hypothesis. Of interest, our meta-regression analysis illustrated that objective measures moderated higher light PA indicating that people with schizophrenia underestimate the time they engage in light PA. Older people with schizophrenia seem to engage in higher levels of light PA than their younger counterparts, suggesting that light PA is preferable to those with established illness. Recent research established that walking is a preferred method of physical activity among people with psychotic disorders (Fraser et al., 2015; Soundy et al., 2014c). Rehabilitation programs should therefore focus in particular on this type of PA, especially in older patients. Research in the general population has demonstrated that walking can reduce diastolic and systolic blood pressure, weight and overall cardiovascular risk (Hanson and Jones, 2015). A previous review (Soundy et al., 2013) found that a paucity of RCTs had investigated walking interventions in people with schizophrenia, but there is evidence to suggest that walking can improve health outcomes in this population. Given our findings, our data suggests that walking might be an appropriate intervention to encourage older people with schizophrenia and established illness to ascertain the benefits of an active lifestyle. Future RCTs are required to test this hypothesis.

However, for optimal health benefits people with schizophrenia should however also strive to engage in moderate to vigorous PA (Vancampfort, 2012). In relation to vigorous PA, it appears that people with schizophrenia engage in on average only 2.4 min per day which is concerning. We did find some interesting differences between levels of moderate and vigorous PA according to the setting and assessment method. While significantly higher levels of moderate PA were observed in outpatients and with objective assessment methods, the opposite was true for vigorous PA, i.e. lower levels were observed in outpatients and with objective assessment methods. These data indicate that people with schizophrenia seem to underestimate their levels of moderate and overestimate their levels of vigorous PA (Rosenbaum and Ward, 2016).

Table 4
Meta-analysis investigating physical activity levels in schizophrenia participants versus controls.

Analysis	Number of studies	Number of participants		Meta-analysis				Publication bias	Heterogeneity
		Schizophrenia	Control	Hedges g	95% CI		p value	Trim and fill effect size (95% CI) [adjusted studies]	I^2
Light Physical activity	4	150	101	−0.262	−0.682	0.1573	0.22	Unchanged	55
Objective	2	48	38	−0.504	−1.30	0.294	0.29	N/A	82
SRQ	2	103	63	−0.131	−0.837	0.575	0.57	N/A	0
Moderate physical activity	5	213	156	−0.446	−0.792	−0.099	**0.01**	−0.63 (−0.97–0.28) [2]	57
Objective	3	110	93	−0.326	−0.840	0.187	0.21	Unchanged	55
SRQ	2	113	63	−0.577	−1.172	−0.089	**=0.04**	N/A	74
Vigorous physical activity	5	213	156	−0.390	−0.602	−0.179	**<0.001**	−0.44 (−0.64–0.25) [2]	0
Objective	3	110	93	−0.315	−0.596	−0.04	**0.02**	Unchanged	1
SRQ	2	113	63	−0.490	−0.812	−0.168	**0.003**	N/A	20
Moderate to vigorous physical activity	2	94	87	−0.480	−0.965	−0.0045	**0.04**	N/A	59

Bold = statistically significant result.

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A potential reason for the overestimation of vigorous PA might be that people with schizophrenia, who are significantly less physically active and physically fit than the general population (Vancampfort et al., 2015b, 2016b), have difficulties in accurately recalling the intensity of various physical activities and therefore perceive moderate intensity physical activities as vigorous. For example, the IPAQ defines vigorous intensity PA broadly as an activity causing significantly harder breathing (Craig et al., 2003). In physically inactive and unfit patients moderate intensity PA might cause people to start already breathing significantly harder. Clinical variability in mood may also influence the ability to accurately respond to self-report questionnaires, especially among people who experience symptom fluctuations (Soundy et al., 2014b). However, in our meta-regression we were unable to identify any potential moderators of moderate and moderate-vigorous PA. Clearly, this calls for the development of accurate and clinically useful measures for clinical practice.

The higher levels of vigorous PA in inpatients are of interest and might be due to the increasing interest for sports as a valuable treatment modality (Soundy et al., 2015), especially when delivered by specialized health care professionals (Vancampfort et al., 2016a). In addition, inpatients are as such more likely to benefit from such expertise and structured planned PA interventions. Our data also indicate that in particular depressive symptoms might be a barrier for engaging in PA. A reason for the association between symptoms of depression and less time spent in vigorous PA might be the fact that feelings of depression are associated with a lower self-efficacy and increased negative outcome expectations when having the intention to engage in sport activities (Kramer et al., 2014). In addition, lower motivation and volition are also key factors (Vancampfort et al., 2014).

Interestingly, we found that over 50% of people with schizophrenia meet the recommended PA guidelines. The results remained robust when we restricted the analysis to objective measures only, although only two studies were included. Of interest, it does appear that there are some slight variations in people with schizophrenia meeting PA guidelines (with lower proportions in community and outpatient settings). However, some caution should be attached to these analyses due to the relatively limited number of studies. Nonetheless, our data demonstrate that people with schizophrenia engage in significantly less moderate and vigorous PA versus controls.

While the results of this meta-analysis are novel, several limitations should be noted. First, almost half of the included studies relied on data drawn from SRQ. Second, we encountered heterogeneity in several of the meta-analyses we undertook, which is expected when pooling observational data (Stroup et al., 2000). However, our meta-regression analyses explained approximately half of the between study heterogeneity that we encountered. Third, there was a paucity of data on PA behavior among people at earlier stages of their illness (e.g. first episode of illness). Finally, there was inadequate information on antipsychotic medication, thus precluding meta-analytical or meta-regression analysis. Future research is required to understand the impact of specific antipsychotics on PA behavior. Nevertheless, allowing for these caveats, the current meta-analysis provides important information for clinicians and researchers.

In conclusion, our data found that people with schizophrenia engage in significantly less moderate and vigorous PA versus controls. People with schizophrenia do not appear to engage in less light PA and future interventions targeting light PA such as walking might offer a unique opportunity to help older people with established illness to experience the health benefits of PA.

Conflict of interests

BS, JF, DV, AB, NV, JW, FS, TC, SR declare that they have no direct conflict of interest.

FG has received honoraria for advisory work and lectures from Roche, BMS, Lundbeck, Otsaka and Sunovion and has a family member with professional links to Lilly and GSK;

ARY has received honoraria for advisory work and lectures from Janssen, Otsuka and Sunovion.

Contributors

BS, DV and JF designed the study. BS, DV, JF conducted the searches. BS, JF, DV and AB extracted the data. BS analyzed the data and wrote the first draft. All authors provided critical revisions of manuscript and approved the final version.

Role of funding source

Funders had no role in the study at any stage.

Key: PA = physical activity, SRQ = self-report questionnaire, Min per day = minutes per day being sedentary, N/A = not applicable.

Key: PA = physical activity, BMI = body mass index, CI = confidence interval, SRQ = self-report questionnaire, PA = physical activity,

Key: CI = confidence interval, SRQ = self-report questionnaire, PA = physical activity.

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