



Physical activity and sedentary behavior in people with bipolar disorder

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Abstract

Background: Mortality rates are approximately two to three times higher in people with bipolar disorder (BD) than in general population. Lack of physical activity (PA) and sedentary behavior (SB) are independent risk factors for cardiovascular disease and premature mortality.

Aims: We conducted a meta-analysis to investigate PA and SB levels and its predictors in BD.

Methods: Major electronic databases were searched from inception till 02/2016 for articles measuring PA and SB with a self-report questionnaire (SRQ) or objective measure (e.g. accelerometer) in BD. A random effects meta-analysis and meta-regression analysis were conducted.

Results: Six studies were eligible including 279 (129[♂]) people with BD (mean age=43.9 years; range: 32.0-51.5 years). The trim and fill analysis demonstrated people with BD spent in total 210.1 min (95%CI=146.3 to 273.9 min) per day being physically active and 613.3 min (95%CI=389.9-836.6 min) during waking hours being sedentary. No significant difference in total PA per day was observed between people with BD and controls ($g=-0.62$, 95% CI=-1.55 to 0.31, $I^2=88.5\%$, $n_{BD} = 82$, $n_{controls} = 86$). Objective measures of PA recorded significantly lower levels ($P=0.03$) compared to self-report PA. Meta-regression demonstrated that older age and a higher body mass index predicted lower PA levels.

Limitations: Only a limited number of studies were identified assessing SB in people with BD.

Conclusions: Adults with BD engage in high levels of sedentary behavior during waking hours. Given that sedentary behavior is an independent predictor of cardiovascular disease, future lifestyle interventions specifically targeting the prevention of sedentary behavior are warranted.

Keywords: physical activity, exercise, sedentary behavior, bipolar disorder

**Physical activity and sedentary behavior in people with bipolar disorder: a systematic review
and meta-analysis**

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Introduction

People with bipolar disorder have higher levels of morbidity and mortality than the general population (De Hert et al., 2011). A recent meta-analysis (Walker et al., 2015) demonstrated that mortality rates are approximately two to three times higher than those of the general population. The higher premature mortality rates are **for an important part** attributable to cardiovascular disease (Goldstein et al., 2015; Vancampfort et al., 2013a). In the general population there is evidence that physical activity and exercise are broadly as effective as pharmacological interventions in preventing cardiovascular disease and mortality (Naci and Ioannidis, 2013). However, people with bipolar disorder experience a range of barriers to engage in physical activity such as lower self-efficacy, presence of medical co-morbidity, lower educational status, and lack of social support (Vancampfort et al., 2013b). Recently, interest has developed in the importance of preventing prolonged periods of sedentary behavior in order to reduce cardiovascular disease and mortality. A large meta-analysis (Biswas et al., 2015) in the general population demonstrated that sedentary behavior is independently associated with an increased risk of developing cardiovascular disease, type two diabetes, and all-cause mortality.

Given that an active lifestyle and reductions in sedentary behavior are related to lower cardiovascular disease risk, understanding physical activity and sedentary behavior levels and their predictors among people with bipolar disorder is critical to improving long-term health outcomes (Ward et al., 2015). To our knowledge, four reviews (Bauer et al., 2016; Kucyi et al., 2010; Stanton and Happell, 2014; Thomson et al., 2015) have considered physical activity as a therapeutic intervention concluding that there is, albeit limited, evidence for its beneficial role on mood, weight, blood pressure, lipid profile, and overall wellbeing. However, several important questions regarding the relationship between physical activity, sedentary behavior and bipolar disorder remain unanswered (Vancampfort et al., 2016a). For instance, the exact levels of physical activity and sedentary behavior among people with bipolar disorder has yet to be established.

Most studies which have measured the level of physical activity and sedentary behavior have used self-report questionnaires (SRQ), rather than objective measures such as accelerometers (Soundy et al., 2014). Since there are concerns that SRQ may overestimate physical activity levels and underestimate sedentary levels in people with bipolar disorder (Soundy et al., 2013; Stubbs et al., 2016), large-scale research is required to establish if SRQ report significantly higher levels of activity than the gold standard objective measurements (Warren et al., 2010).

Next to this, it is of interest to explore whether geographical differences and differences between settings (e.g., outpatients versus inpatients) in physical activity and sedentary behavior exist as such differences might help researchers and clinicians to identify specific environmental factors (e.g. differences in health-related policies, available facilities, etc.) which should be considered.

In addition, it remains unclear if people with bipolar disorder engage in more or less physical activity and sedentary behavior compared to healthy controls, and what factors moderate physical activity participation and sedentary behavior in this population. Therefore, we conducted a systematic review to: (1) establish the mean time spent physically active (at light, moderate and high intensity) and sedentary per day, in people with bipolar disorder (2) investigate differences between SRQ and objective measures, (3) investigate predictors of physical activity and sedentary behavior using meta-regression analyses and (4) explore differences in physical activity and sedentary behavior in people with bipolar disorder versus age- and gender matched healthy controls.

Methods

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

Inclusion criteria

We included studies that: (1) involved adult participants with a diagnosis of bipolar disorder according to established criteria (e.g., DSM (American Psychiatric Association, 2013), or ICD (WHO, 1993)). If we encountered studies including mixed samples of mental illnesses (e.g. major depressive disorders) we attempted to extract the data for those with bipolar disorder. If the data were not available in the paper, the authors were contacted twice in a two-week period. (2) Measured physical activity and sedentary behavior using either a SRQ (e.g. International Physical Activity Questionnaire (IPAQ), (Craig et al., 2003)) or objective measure (e.g. accelerometer). Physical activity was defined as any interventions that use bodily movement produced by skeletal muscles and which requires energy expenditure (Caspersen et al., 1985) while sedentary behavior is defined as an energy expenditure ≤ 1.5 metabolic equivalents of task (METs), while in a sitting or reclining posture during waking hours (Cart, 2012). (3) Were interventional (RCTs, CCTs) or observational (prospective or cross sectional) studies conducted in any setting (inpatients or outpatients). (4) Were published in an international peer-reviewed journal.

Exclusion criteria

Exclusion criteria were: (1) non-quantitative studies, (2) not including people with bipolar disorder or not reporting the data for those with bipolar disorder in mixed sample studies, (3) no adequate measure of physical activity or sedentary behavior (i.e. no mean time (minutes) per day engaged in light, moderate or high intensity physical activity or sedentary behavior).

Search strategy

Two independent authors searched PubMed, PsycARTICLES, SPORTDiscus, and CINAHL Plus without language restrictions from inception till February 1st 2016, using the keywords: 'bipolar' AND 'physical activity' OR 'exercise' OR 'sedent*' OR 'sitting OR 'lying' OR 'screen time'. In addition, reference lists of all eligible articles and related systematic reviews were screened to identify

potentially eligible articles. Clinicaltrials.gov, www.crd.york.ac.uk/prospero and www.who.int/trialsearch were searched to identify any unpublished trials.

Study selection

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

Outcomes

The primary outcome was the mean time (minutes) per day that people with bipolar disorder engaged in physical activity or were sedentary. We collected separate data for light, moderate and high intensity physical activity as defined by the original authors if these data were reported. We also collected data on physical activity behavior among healthy controls where reported.

Data extraction

One author (DV) extracted data using a predetermined data extraction form, which was subsequently validated by a second author (JF). The data extracted included first author, country, setting, population, type of the study (prospective, controlled or randomized controlled trial), number of studies, psychotropic medication use (% on antipsychotic medication, % on antidepressants, % on lithium, % on valproic acid, % on lamotrigine), and participants included in the article (including mean age, % male, level of depressive and manic symptoms), physical activity and sedentary behavior assessment method (objective or self-report), type of behavior (e.g. sitting or lying down or aerobic physical activity and resistance training) and the primary outcomes. In case data were not available we contacted the authors to request the data needed.

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 (total and at light, moderate and high intensity) spent in physical activity per day and the mean amount of time per day spent sedentary (minutes per day) together with the 95% confidence intervals (CI). Second, we calculated the

subgroup differences in physical activity and sedentary behavior and guidelines adherence according to the measurement (self-report versus objective measurement). Third, we investigated potential moderators of physical activity and sedentary behavior in people with bipolar disorder with meta-regression analyses. The potential moderators of interest were mean age, % of males, assessment method (objective versus self-report), illness duration, body mass index and psychiatric symptoms. Fourth, we conducted a comparative meta-analysis investigating differences in physical activity and sedentary behavior and healthy 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 in levels of physical activity and sedentary behavior. Heterogeneity was assessed with the I^2 statistics for each analysis (Higgins, 2011). Publication bias was assessed with the Begg-Mazumdar Kendall's tau (Begg and Mazumdar, 1994). For all analyses we calculated the 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.

Results

Search results

The initial search yielded 2,525 results. After removal of duplicates and exclusion at the title/ abstract level, 34 abstracts were retrieved in full. At the full text review stage, 27 articles were considered and 19 were subsequently excluded (see Figure 1 for search results). One of three contacted research groups provided additional data (see acknowledgements). Overall, 8 articles, reporting data from 6 unique studies, were eligible for inclusion (Janney et al., 2014; Masa-Font et al., 2015; McGlinchey et al., 2014; Vancampfort et al., 2015a,b & 2016b) (including 7 analyses as one study (Vancampfort et al., 2016b) provided subjective and objective data). Two studies with overlapping samples (Vancampfort et al., 2015c,d) were only included in the comparison analyses as in the original studies no control subjects were included. Full details of the included studies are summarized in Table 1.

Insert Figure 1 about here

Study and participants' characteristics

Across the 6 unique cross-sectional studies, there were 279 (129[♂]) individuals with bipolar disorder (mean age=43.9 years; range: 32.0-51.5 years). The sample size ranged from 20 to 69. Three studies were conducted in Belgium, two in the USA and one in Spain. Three studies were carried out in an outpatient setting, one in an inpatient setting, one in a community setting and one in a mixed setting. Of the studies reporting outcome data for body mass index (BMI), the mean BMI ranged from 25.6 to 33.6. In 3 studies reporting on the bipolar disorder subtype, the percentage of people with type 1 bipolar disorder ranged from 68% to 100%. Three studies reported general population control data. In total 82 (38[♂]) age- and gender matched controls were included (mean age=40.5 years). Further details of the included studies are summarized in Table 1.

Insert Table 1 about here

Meta-analysis of the time spent physically active and sedentary

Results of the meta-analyses are summarized below. Full details are presented in Table 2.

Sedentary behavior

Across 3 studies, 149 patients spent 613.3 minutes (equivalent to 10 hours and 13 minutes) per day sedentary (95%CI=389.9 to 836.6min). There was no publication bias (Kendall's tau with continuity correction=-0.67 P=0.30) and the trim and fill adjusted analysis did not change the sedentary time.

Physical activity

Five studies reported the total time spent physically active across 207 patients with bipolar disorder. The total time spent physically active was 254.6 minutes per day (equivalent to 4 hours and 15 minutes). Although there was no evidence of publication bias (Kendall's tau with continuity correction=0.30, P=0.46), the total time spent physically active per day was 210.1 minutes per day after correcting for this (equivalent to 3 hours and 30 minutes). When looking at the different physical activity intensities, five studies (n=187) provided data on the time spent in vigorous physical activity. Patients with bipolar disorder spent a mean of 23 minutes per day in vigorous physical activity. There was no publication bias (Kendall's tau with continuity correction=0.30, P=0.46) and the trim and fill adjusted analysis did not change the time spent in vigorous physical activity. Five studies (n=187) demonstrated that patients with bipolar disorder engaged in a mean of 95 minutes per day in moderate intensity physical activity. There was no publication bias (Kendall's tau with continuity correction=0.30, P=0.46) and the trim and fill adjusted analysis did not change the time spent in moderate physical activity. Finally, 5 studies (n=195) provided data on the time spent in light physical activity. Patients with bipolar disorder spent a mean of 152.6 minutes per day in light physical activity (equivalent to 2 hours and 33 minutes). Although there was no publication bias (Kendall's tau with continuity correction=0.0, P=1.0), the total time spent in light physical activity per day was corrected to 124.5 minutes per day.

Subgroup analyses

Regional differences (USA versus Europe)

Table 2 shows that the mean time spent sedentary in USA studies (n=60) was significantly higher ($P<0.001$) than in European studies (n=89). The mean time spent physically active in USA studies (n=92) was significantly ($P=0.03$) lower than the pooled time spent physically active in European studies (n=135).

Settings (inpatients versus outpatients versus mixed settings versus community settings)

There was no difference in sedentary behavior between mixed (n=69) and outpatient (n=80) settings. Patients in community settings (n=32, 127.6 min, 95%CI=97.5 to 157.7) engaged in significantly less physical activity than patients in inpatient settings (n=46, 285.7min, 95%CI=213.5 to 357.8, $P<0.001$). Details are summarized in Table 2.

Assessment method (subjective versus objective)

The pooled time in sedentary behavior in objective measures of sedentary behavior (n=80) was not significantly higher than in self-report measures (n=69) ($P=0.13$). In contrast, the pooled time spent in physical activity measured by objective measures (n=80) was significantly ($P=0.03$) lower than in self-report measures (n=135).

Insert Table 2 about here

Meta-regression analyses.

There were insufficient data to explore to explore the effect of depressive and manic symptoms and of psychotropic medication use (% on antipsychotic medication, % on antidepressants, % on lithium, % on valproic acid, % on lamotrigine). Older age and a higher BMI were predictive of less time spent in light intensity physical activity (see Table 3). Similarly, higher BMI was predictive of less time spent in moderate intensity physical activity, and older age was predictive of less time spent in vigorous physical activity. Due to limited data, no predictors for sedentary behavior could be calculated.

Insert Table 3 about here

Differences with age- and gender matched general population controls

There were insufficient data to explore differences in sedentary behavior between people with bipolar disorder and controls. The reduced amounts of physical activity observed in people with bipolar disorder did not significantly differ from controls ($g=-0.62$, 95% CI=-1.55 to 0.31, $I^2=88.5\%$, n bipolar disorder = 82, n controls = 86) (see Figure 2).

Insert Figure 2 about here

Discussion

The current study is, to our knowledge, the first to investigate physical activity, sedentary behavior, and its predictors in people with bipolar disorder using meta-analytic techniques. We found that people with bipolar disorder spent 613.3 min (95%CI=389.9-836.6 min) per day sedentary, equivalent to 10 hours and 13 minutes) and are physically active on average, during waking hours for 210.1 minutes per day (equivalent to 3 hours and 30 minutes). The pooled time spent in physical activity as assessed by objective measures was significantly lower than ($P=0.03$) self-report measures, i.e. 178.9 minutes per day or 2 hours and 59 minutes ($P=0.03$). Thus, our results suggest that current questionnaires do not accurately collate data on physical activity behavior, and significantly over-estimate activity in this at risk group. Some of this may be due to the cognitive deficits associated with bipolar disorder (Samamé et al., 2014) leading to an overestimation within self-report measures. Also clinical variability in mood may influence the ability to accurately respond to self-report questionnaires, especially among people who experience quick symptom fluctuations such as rapid-cycling bipolar disorder. Reliable and valid physical activity instruments that accurately capture sedentary behaviors and physical activity at the lowest end of the physical activity continuum in people with mood disorders have not been developed to date (Soundy et al., 2014). One of the most important challenges in physical activity research in people with bipolar disorder therefore is producing a low cost, easily administered, reliable and valid physical activity questionnaire that captures sedentary behaviors and physical activities at the lowest end of the physical activity spectrum. Next to these differences between objective and subjective measures, our data also demonstrated geographical differences with higher levels of sedentary behavior and lower levels of physical activity in North-American versus European studies. One reason might be that it is more common in European countries to include physical activity interventions in the multidisciplinary treatment of people with mental illness (Probst, 2012; Probst et al., 2010). The observation that physical activity levels were higher in inpatient than in community settings seems to confirm this hypothesis. Meta-regression analyses, on its turn, demonstrated that older age, and higher BMI predict lower levels of physical activity. The observation that older age and higher BMI were significant predictors of lower physical activity levels is a relationship also seen in the general population (Bauman et al., 2012). These data indicate that in physical activity interventions for people with bipolar disorder, consideration should be given to older people and those who are overweight. Previous research has demonstrated that older age- and overweight related foot or ankle problems

and back pain in persons with bipolar disorder impair activities of daily life, even in middle-aged patients (Vancampfort et al., 2015). The assessment and treatment of such pain should form an integral part of the management of bipolar disorder (Stubbs et al., 2015a) and addressing pain may offer an important strategy to increase physical activity and reduce sedentary behavior.

Although we were not able to explore differences in sedentary behavior between patients and healthy controls, spending more than 10 hours per day sedentary is substantially higher than reported in older people (>60 years) (mean=5.3 h per day) (Harvey et al., 2014), but slightly lower than in people with psychosis (mean=12.6 hours per day) (Stubbs et al., 2016). Given that prolonged sedentary behavior is independently associated with metabolic syndrome (Vancampfort et al., 2012), elevated c-reactive protein (Stubbs et al., 2015b), diabetes, cardiovascular disease, cancer and mortality (Biswas et al., 2015) the seemingly high levels of sedentariness among people with bipolar disorder are concerning. Research is urgently needed to compare levels of sedentary behavior between people with bipolar disorder and age- and gender matched healthy controls. Based on available evidence, clinicians, however, cannot delay their intervention until more evidence becomes available. Rather, immediate action should be taken to promote a reduction of sedentary behaviors by introducing light activity throughout the day. Advice on how to increase time spent in light physical activity could include: (i) getting up from the chair and moving around during television commercial breaks, or (ii) adding five minute walks throughout the day, for example walking short distances rather than using motorized transport (Vancampfort et al., 2015e). Adopting small, but incremental lifestyle changes may then position sedentary people with bipolar disorder to transition to brief bouts of moderate-to-vigorous intensity physical activity as well as muscle strengthening activities in order to significantly improve long-term health outcomes (Vancampfort et al., 2015f). The observation in this meta-analysis that there was no difference in physical activity levels between people with bipolar disorder and matched controls warrants further investigation. It might be hypothesized that people with bipolar disorder are not necessarily less physically active, although caution is needed in making any conclusions as these particular results were only based on 3 studies.

Several limitations of this meta-analysis should be noted. First, half of the included studies relied on data drawn from subjective assessment methods. Second, we encountered heterogeneity in the meta-analysis, but were able to examine this heterogeneity in the meta-regressions. Third, there was a paucity of data on sedentary behavior among people with bipolar disorder. It is important that

future research should seek to investigate sedentary behavior in this vulnerable population. Finally, there was inadequate information on medication use (% on antipsychotic medication, % on antidepressants, % on lithium, % on valproic acid, % on lamotrigine) and on depressive and manic symptoms, thus precluding meta-analytical or meta-regression analysis. Future research is required to understand the impact of psychiatric symptoms and medication use on physical activity and sedentary behavior in this population. Nevertheless, allowing for these caveats, the results provide important information for clinicians and researchers.

In conclusion, although our data show that people with bipolar disorder were not less physically active than healthy controls, the observed sedentary behavior levels are high, up to double the level observed in elderly. Given these very high levels of sedentary behavior among people with bipolar disorder and the overwhelming deleterious impact of this on cardiovascular health, future lifestyle interventions specifically targeting sedentary behavior are warranted as a priority.

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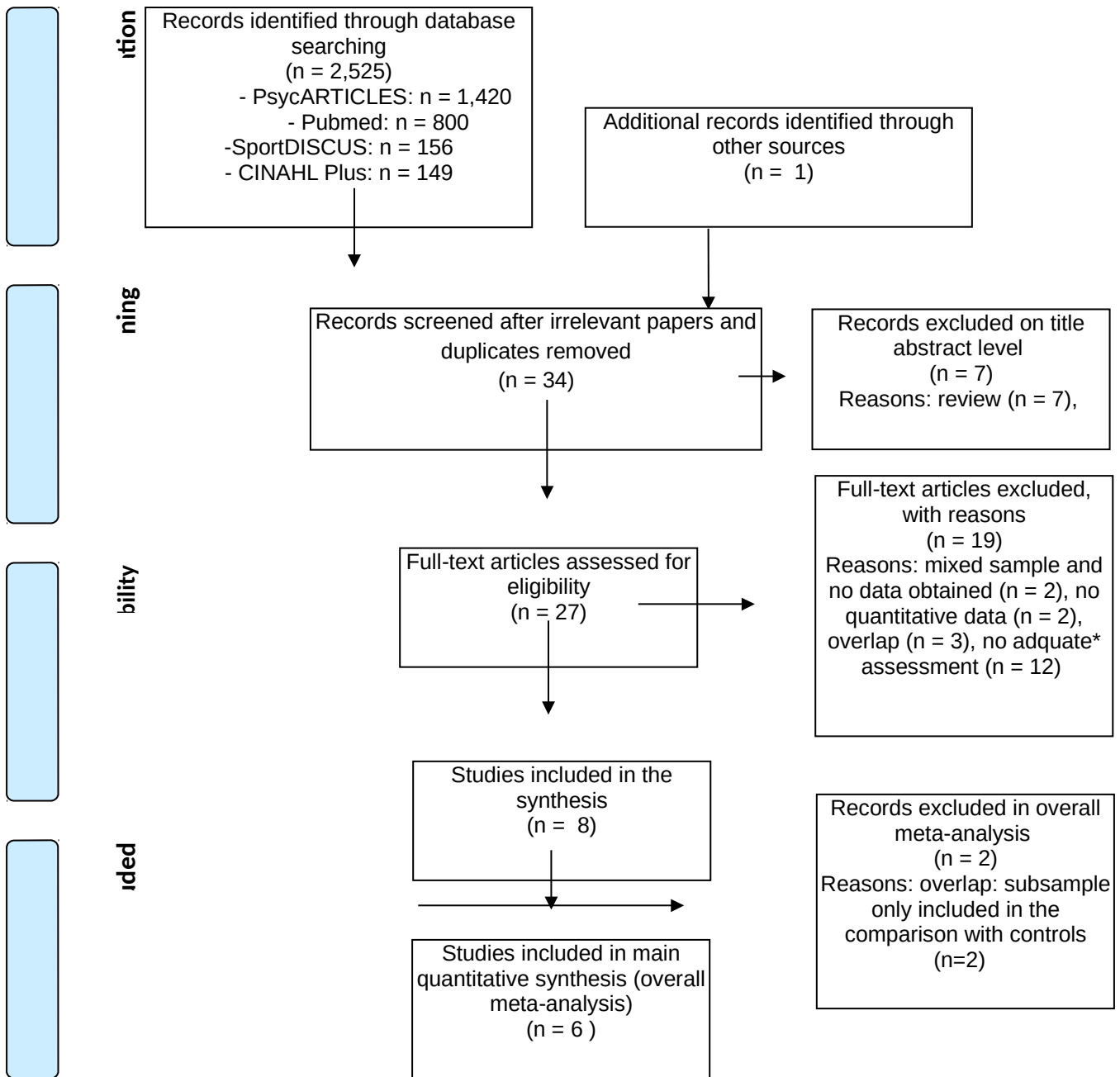
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Figure 1. Flow diagram for the search results



*no mean time (minutes) per day engaged in physical activity or sedentary behavior.

Table 1. Details of the included studies

Author	Study setting and location	Participants	Assessment method and period	Physical activity and sedentary behavior (min/day)	Controls
Janney et al. 2014	Outpatients USA	60 (21 σ); DSM-IV; BP-I (68%), BP-II (28%), BP NOS (4%); 45.3 \pm 12.2 years; BMI=28.9 \pm 6.9; HRSD=7.9 \pm 6.3, YMRS=3.2 \pm 3.6	Objective: ActiGraph AM-7164, 7 days wear time	PAL=215 \pm 80 PAM+PAH=14 \pm 15 TPA=229 \pm 87 SB=812 \pm 168	None
McGlinchey et al., 2014	Community patients USA	32 (12 σ); DSM-IV; BP-I (100%); 34.7 \pm 10.5 years; 15/32 antidepressants, 13/32 lamotrigine, 5/32 lithium, 3/32 valproic acid, 20/32 antipsychotics IDS-C=8.6 \pm 4.7, YMRS=3.2 \pm 3.0	Mini Mitter AW64 Actiwatch Inc, wear time not specified, total entire BP sample=50 days	TPA=127.6 \pm 86.8	36(17 σ); 33.3 \pm 12.6 years TPA=109.0 \pm 62.8
Masa-Font et al., 2015	Outpatients Spain	52 (21 σ); 51.5 \pm 8.3 years; BMI=33.6 \pm 5.0	IPAQ, 7 days recall	PAL=53.2 \pm 59.5 PAM=8.4 \pm 24.2 PAH=4.9 \pm 20.1	None
Vancampfort et al., 2015a	Inpatients Belgium	46 (24 σ); DSM-IV; BP-I (91.3%); 44.5 \pm 11.6 years; BMI=26.0 \pm 5.3; 10/46 antidepressants, 0/46 lamotrigine, 15/46 lithium, 14/46 valproic acid, 45/46 antipsychotics QIDS-SR=7.5 \pm 5.0, HCL-32=15.6 \pm 6.6	IPAQ, 7 days recall	PAL=173.1 \pm 144.8 PAM=87.7 \pm 116.1 PAH=36.5 \pm 67.7 TPA=285.7 \pm 249.6	None
Vancampfort et al., 2015b	Mixed setting Belgium	69 (36 σ); DSM-IV; 42.6 \pm 11.8 years; BMI=25.6 \pm 4.9	IPAQ, 7 days recall	PAL=151.1 \pm 136.4 PAM=80.1 \pm 107.4 PAH=56.3 \pm 82.8 TPA=287.6 \pm 238.2 SB=543.2 \pm 299.9	None

Table 1. Continued

Author	Study setting and location	Participants	Assessment method and period	Physical activity and sedentary behavior (min/day)	Controls
Vancampfort et al., 2015c*	Inpatients Belgium	30 (16 ♂); DSM-IV; 40.8±11.6 years; 8/30 antidepressants, 2/30 lamotrigine, 10/30 lithium, 9/30 valproic acid, 29/30 antipsychotics QIDS-SR=6.8±4.5, HCL-32=15.1±6.3	IPAQ, 7 days recall	PAL=63.9±47.5 PAM=28.7±29.0 PAH=5.8±9.2 TPA=98.4±64.7	30 (16 ♂); 40.5±10.8 years PAL=75.2±47.5 PAM=65.9±57.9 PAH=9.3±9.7 TPA=157.4±84.6
Vancampfort et al., 2015d*	Outpatients Belgium	20 (6 ♂); DSM-5; 47.9±7.9years	Bodymedia Sensewear Armband, 7 days wear time	TPA=137.0±81.6	20 (6 ♂); 47.8±7.6 years TPA=237.2±56.2
Vancampfort et al., 2016b	Outpatients Belgium	20 (6 ♂); DSM-5; 47.4±8.4years; BMI=26.3±5.2	Bodymedia Sensewear Armband, 7 days wear time IPAQ, 7 days recall	PAM=144.7±84.9 PAH=5±7.5 SB=480.0±167.0 PAL=174.7±150.7 PAM=168.5±145.1 PAH=39.7±63.0 TPA=383.0±211.7	None

*Only included in the comparison analyses with controls: data on patients with bipolar disorder are presented in a larger sample elsewhere; BP=bipolar disorder, NOS=not otherwise specified, BMI=body mass index, PAL=Physical activity low intensity, PAM= Physical activity moderate intensity, PAH= Physical activity high intensity, TPA=total physical activity, IPAQ=International Physical Activity Questionnaire, HRSD=Hamilton Rating Scale for Depression, 17-item, YMRS=Young Mania Rating Scale; IDS-C=Inventory of Depressive Symptomatology – Clinician Rating; QIDS-SR=Quick Inventory of Depressive Symptomatology self-report; HCL-32=Hypomania Checklist-32.

Table 2. Meta-analytic results of the time spent physically active and sedentary in people with bipolar disorder

Analysis	N studies	N participants	Meta-analysis			Trim and fill adjusted ES	I ²
			Time per day (min)		95%CI		
<i>Main analysis</i>							
Sedentary behavior	3	149	613.3	389.9	836.6	613.3 (389.9-836.6)	97.5
Light intensity PA	5	195	152.6	73.5	231.8	124.5 (47.9-201.1)	97.5
Moderate intensity PA	5	187	94.6	33.1	156.1	94.6 (33.1-156.1)	96.4
Vigorous PA	5	187	23.3	10.3	36.3	23.4 (10.3-36.4)	90.0
Total PA	5	207	254.6	182.4	326.9	210.1 (146.3-273.9)	92.9
<i>Region</i>							
Sedentary behavior							98.4
Europe (Belgium, Spain)	2	89	512.3	450.4	574.2	N/A	
USA	1	60	812.0	94.2	1529.8	N/A	
Total PA							92.9
Europe (Belgium, Spain)	3	135	314.6	230.5	398.7	N/A	
USA	2	92	178.9	88.2	269.7	N/A	
<i>Setting</i>							
Sedentary behavior							98.4
Outpatient setting	2	80	647.3	322.0	972.3	N/A	
Mixed setting	1	69	543.2	81.5	1004.9	N/A	
Total PA							92.9
Inpatient setting	1	46	285.7	70.7	500.7	N/A	
Outpatient setting	2	80	299.1	148.8	449.4	N/A	
Community setting	1	32	127.6	77.1	332.3	N/A	
Mixed setting	1	69	287.6	77.4	497.7	N/A	
<i>Assessment method</i>							
Sedentary behavior							98.4
Subjective	1	69	543.2	192.8	893.6	N/A	
Objective	2	80	647.4	322.0	972.7	N/A	
Total PA							92.9
Subjective	3	135	314.6	88.2	269.7	N/A	
Objective	2	80	178.9	230.5	398.7	N/A	

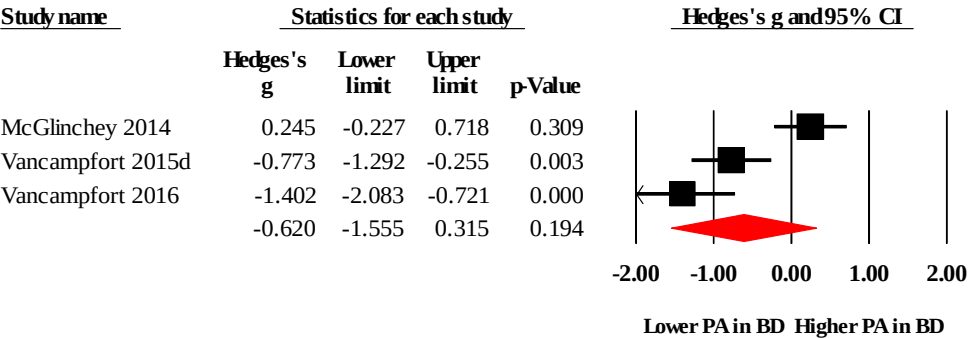
ES=Effect size, PA= physical activity, N/A=not applicable.

Table 3. Meta-regressions of moderators for physical activity behavior in people with bipolar disorder

Moderator	N studies	β	95%CI		P-value	R ²
<i>Light intensity PA</i>						
Age	5	-13.6	-24.5	-2.8	0.01*	0.59
% male	5	-1.1	-6.3	4.1	0.68	0.03
BMI	5	-13.2	-25.4	-1.1	0.03*	0.51
Objective measurement	5	-83.0	-181.9	15.8	0.10	0.39
<i>Moderate intensity PA</i>						
Age	5	-6.4	-20.4	7.7	0.38	0.19
% male	5	-3.1	-6.2	0.04	0.05	0.44
BMI	5	-13.0	-20.7	-5.3	<0.001*	0.78
Objective measurement	5	-66.7	-171.8	38.3	0.21	0.30
<i>Vigorous PA</i>						
Age	5	-5.4	-8.9	-1.8	0.003*	0.72
% male	5	0.43	-1.0	1.88	0.55	0.10
BMI	5	-3.8	-8.5	0.91	0.11	0.36
Objective measurement	5	26.6	-9.9	63.1	0.15	0.31

PA= physical activity, BMI=body mass index, *Significant when P<0.05.

Figure 2. Comparison of total physical activity levels between patients with bipolar disorder and matched general population controls.



Author disclosure**Contributors**

DV, JF and BS conceived and developed the study design. DV, JF and BS collected the data. BS performed the statistical analyses in consultation with DV. DV, JF and BS wrote the first draft of the manuscript. All authors provided critical comments and developed the manuscript into its submitted form. All authors approved the final version.

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Conflicts of interest

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