

The physical activity profiles of patients with persecutory delusions

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ABSTRACT

Background: Severe paranoia is likely to limit engagement in physical activities. In this study we set out to examine for the first time the activity profiles of patients with current persecutory delusions and the associations with psychiatric symptoms.

Method: Seventy-five patients with persecutory delusions in the context of non-affective psychosis wore a pedometer for seven days. Participants completed measures of meaningful activity, mobility, and psychiatric symptoms. Latent class analysis was used to identify physical activity profiles.

Results: Three distinct activity profiles emerged: a mobile but inactive group ($n = 47$, 63%) (mean daily step count = 6453, $SD = 3348$), an immobile and inactive group ($n = 20$, 27%) (mean daily step count = 4205, $SD = 2442$), and a mobile and active group ($n = 8$, 11%) (mean daily stepcount = 18396, $SD = 5715$). The groups did not significantly differ in their levels of paranoia, anhedonia, psychological wellbeing, insomnia, beliefs about self or others, or safety-seeking behaviours. There were significant group differences in depression and number of physical health appointments, with the immobile and inactive group showing higher levels of both. There were indications of group differences in body mass index, hours worked, hallucinations, and worry.

Conclusion: There are likely to be different physical activity profiles for patients with current psychotic experiences. The majority of people with persecutory delusions are physically inactive, but a small minority are highly active. In those patients who have low activity levels, there is a potentially important distinction in self-reported mobility, which warrants further investigation. Treatments designed to improve physical activity levels may need to tailor by activity profile.

1. Introduction

Individuals diagnosed with psychosis are three times more likely to have poor physical health than other members of the general population (Working Group for Improving the Physical Health of People with SMI, 2016). One contributory cause of poorer physical health is physical inactivity. People with psychosis are less physically active than other members of the general population, on average spending 11 h a day being sedentary (Stubbs, Williams, Gaughran, & Craig, 2016) and engaging in significantly less moderate or vigorous activity (Stubbs, Firth, et al., 2016). Both sedentary behaviours and lack of physical activity are independently linked to poor physical health, including all-cause mortality, cardiovascular disease, cancer, and type II diabetes (Biswas et al., 2015). Inactivity also has a significant impact, typically in a reciprocal relationship, on psychosocial functioning, short-term

memory, sleep, depression, and negative symptoms (Cooney et al., 2013; Firth, Cotter, Elliott, French, & Yung, 2015). One important indicator of physical activity is the number of steps taken. Independent of walking speed or intensity, lower step count is associated with a higher body mass index (BMI) and body fat (Tudor-Locke et al., 2001) and cardiovascular disease (Hamer & Chida, 2008). In this paper, we focus on activity levels assessed by step count of individuals with current persecutory delusions.

Approximately 70% of people diagnosed with non-affective psychosis experience persecutory delusions (Coid et al., 2013). Paranoia, across the population, is associated with poor physical health and increased service use (Freeman et al., 2011). Holding persecutory beliefs is highly likely to impede physical activity. Feeling very unsafe could mean that people may not even leave the house, with three-quarters of individuals with severe paranoia having levels of anxious avoidance

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equivalent to agoraphobia (Freeman, Taylor, Molodynski, & Waite, 2019). However, our clinical experience is not that every individual with a persecutory delusion is physically inactive – there are likely to be distinct activity profiles within this clinical population.

For many years activity levels were measured using self-report assessments but this is well known to under-estimate activity levels in the general population (Tudor-Locke, 2001), including for people with non-affective psychosis (Stubbs, Williams, et al., 2016). It is therefore recommended that studies of physical activity use accelerometers (Firth et al., 2018). At the baseline assessment of a randomised controlled trial for the treatment of persecutory delusions (Freeman, Emsley, et al., 2021) we therefore included accelerometer assessment. We aimed to conduct activity profiling, examining a group of activity indicators simultaneously in order to determine patterns in the data. Levels of meaningful activity and mobility are both likely to impact upon the experience of persecutory delusions. They might also be important mediators of physical activity and as such could be key to facilitating it. Activity profiling allows details in the data to emerge which may otherwise be masked by using the average activity level across the whole group. Tudor-Locke and colleagues (Tudor-Locke, Brashear, Johnson, & Katzmarzyk, 2010) have used this approach to identify physical activity treatment targets for people of differing BMI.

Having identified potential activity profiles, we then wished to test for correlates that may plausibly contribute to, or be consequences of, differing activity levels.

2. Method

2.1. Participants

Seventy-five patients who took part in the baseline assessment for the Feeling Safe clinical trial participated in the current study (Freeman, Emsley, et al., 2021; Freeman et al., 2016). The Feeling Safe clinical trial received approval from an NHS Research Ethics Committee (South Central – Oxford B Research Ethics Committee; ref 15/SC/0508) and all participants gave written informed consent. Patients with a primary diagnosis of non-affective psychosis and a persistent persecutory delusion (for a minimum of 3 months), currently held with at least 60% conviction, were recruited from three NHS mental health trusts in the UK. The participants in the current study were the first cohort taking part in the trial.

2.2. Measures

2.2.1. Activity measures

2.2.1.1. Step count. The Fitbit Charge (first model – Fitbit Inc., San Francisco, California, USA) is a wearable activity monitor with a 3-axis accelerometer, enabling accurate measurement of daily step count. Fitbit devices were selected as they presented an affordable, unobtrusive and easy to use way of measuring stepcount, which participants found acceptable. These devices are widely used in research studies (Henriksen et al., 2018). The devices were worn on the non-dominant arm for one week and data were recorded for participants who reported that they had worn the device for at least three full days. Wear patterns were examined and days recording no steps were removed from the analysis, as it was assumed that participants may have removed the device. No participants were excluded on this basis. Step count data were downloaded after a period of seven days.

2.2.1.2. Meaningful activity (Time budget (Jolley et al., 2006)). The Time Budget assesses meaningful activity levels over the past week through a structured interview conducted by trained research assistants under the supervision of clinical psychologists. Interviewers start with the activity performed on the preceding day, asking for detail on activities and social

contact in each time period. Interviewers check that the week recorded is representative of a typical week. A participant's activity is rated within four time blocks per day over 7 days, with higher scores indicating higher levels of meaningful activity. Ratings for each block are: 0 = 'nothing', 1 = 'predominantly passive activity', 2 = 'independent activity requiring some planning and motivation', 3 = 'several 2-rated activities completely filling a time period or a more complex and demanding, but shorter, activity', 4 = 'time period filled with a variety of demanding independent activities'.

2.2.1.3. Mobility (EuroQol (EQ-5D) mobility item (Brooks, Rabin, & De Charro, 2013)). The single mobility item from the EuroQoL (EQ-5D) (Brooks et al., 2013) was used to measure mobility. Mobility is rated on a five-point scale: 1 = 'I have no problems in walking about', 2 = 'I have slight problems in walking about', 3 = 'I have moderate problems in walking about', 4 = 'I have severe problems in walking about', 5 = 'I am unable to walk about'. Higher scores indicate poorer mobility.

2.2.2. Psychiatric symptoms

2.2.2.1. Paranoia (The revised green et al. Paranoid thoughts scale, R-GPTS (Freeman, Loe, et al., 2021)). The R-GPTS is a self-report measure of paranoid thinking over the previous fortnight containing two separate scales. The 8-item social reference scale assesses ideas of reference, whilst the 10-item persecution scale assesses ideas of persecution. Items are rated on a 5-point scale (0 = 'Not at all', 4 = 'Totally') with higher scores indicating greater levels of paranoid thinking.

2.2.2.2. Depression (Beck depression Inventory-II, BDI (Beck, Steer, & Brown, 1996)). The BDI-II is a self-report 21-item scale assessing depression severity over the past fortnight. Each item is rated on a 4-point scale (0–3) with higher scores indicating higher levels of depression.

2.2.2.3. Wellbeing (Warwick-Edinburgh mental well-being scale, WEMWBS (Tennant et al., 2007)). The WEMWBS is 14-item self-report scale assessing psychological wellbeing over the period of the last fortnight. Items are rated on a 5-point scale (1 = *none of the time*, 5 = *all of the time*) and higher scores indicate greater levels of wellbeing.

2.2.2.4. Worry (Penn state worry questionnaire, PSWQ (Meyer, Miller, Metzger, & Borkovec, 1990)). The PSWQ is a self-report measure of trait worry style. Each of the sixteen items is rated on a 5-point scale (1 = *'not at all typical of me'*, 5 = *'very typical of me'*). Higher scores indicate a greater tendency to worry.

2.2.2.5. Safety-seeking behaviours (Safety behaviours questionnaire—Persecutory delusions, SBQ (Freeman, Garety, & Kuipers, 2001)). The SBQ is a semi-structured interview assessing the use of safety-seeking behaviours (i.e. actions aiming to reduce persecutory threat). For each safety behaviour that is elicited, participants rate its frequency over the past month on a 4-point scale (1 = *'behaviour definitely occurred on at least one occasion'*, 4 = *'present more or less continuously'*). Higher scores indicate greater use of safety-seeking behaviours.

2.2.2.6. Insomnia (Insomnia severity Index, ISI (Bastien, Vallieres, & Morin, 2001)). The ISI is a seven-item self-report questionnaire assessing insomnia symptoms over the past fortnight. Each item is rated on a 0–4 scale. Higher scores indicate higher levels of insomnia.

2.2.2.7. Hallucinations (Cardiff anomalous perceptions scale – Hallucinations, CAPS (Bell, Halligan, & Ellis, 2006)). The 11-item self-report hallucinations scale of the CAPS assesses the frequency of hallucinations across multiple sensory modalities. Items are rated on a 0–5 scale (0 = *'not at all'*, 5 = *'daily'*), with higher scores indicating more frequent

hallucinations.

2.2.2.8. Anhedonia (*The temporal experience of pleasure scale, TEPS* (Gard, Gard, Kring, & John, 2006)). The 10-item self-report TEPS scale assessing anticipatory pleasure was used as a marker of anhedonia. Each item is rated on a 6-point scale (1, very false for me to 6, very true for me). Higher scores indicate lower levels of anticipatory pleasure.

2.2.2.9. Negative core beliefs (*Brief core schema scales, BCSS* (Fowler et al., 2006)). The 6-item negative-self subscale was used as a measure of negative beliefs about the self and the 6-item negative-other subscale was used as a measure of negative beliefs about other people. Items are rated on a five-point scale (0 = 'not at all', 4 = 'totally'). Higher scores indicate more strongly held negative beliefs.

2.2.3. Service use

GP and outpatient hospital appointments for physical health over the previous six months were self-reported.

2.2.3.1. Antipsychotic medication. Data on antipsychotic medication were collected and transformed to a defined daily dose (DDD) to allow comparability (Nosè et al., 2008). The DDD is defined by the World Health Organisation as "the assumed average maintenance dose per day for a drug used for its main indication in adults" (<https://www.who.int/tools/atc-ddd-toolkit/about-ddd>).

2.3. Statistical analyses

Statistical analyses were conducted using R version 3.6.1 (Core Team, 2013). Latent profile analysis (LPA) was used to examine different activity profiles in the patient group. LPA is a latent variable modelling technique to estimate distinct subgroups of participants, or profiles, with similar response patterns on key indicators. Using the 'tidyLPA' package (Rosenberg, Beymer, Anderson, van Lissa, & Schmidt, 2019), LPA analysis was conducted based on the physical activity variables of mean step count, meaningful activity (Time Budget), and mobility (EQ-5D). We first compared the fit indices of models with between one and six profiles with either: 1) equal residual variances and covariances constrained to zero; 2) freely estimated residual variances and covariances constrained to zero; 3) equal variances and equal covariances; and 4) varying variances and varying covariances. To determine the best fitting solution, we examined models with lower Bayesian Information Criteria (BIC) values and conducted a bootstrapped likelihood ratio test (BLRT) (McLachlan & Peel, 2000). For each model, the BLRT examines whether the addition of each profile significantly improves model fit. Classification fit of the final model was assessed by the entropy values and the minimum and maximum probabilities for latent class membership, with values ranging from 0 to 1 and higher values indicate greater classification certainty.

The estimated means and variances of the three activity variables for each of the profiles in the final model are described. One-way ANOVAs were used to assess the differences between profile subgroups on each of the continuous variables of interest. Post-hoc comparisons were conducted for variables with a significant group effect using Tukey's HSD to assess the significance of each pairwise comparison. Fisher's exact tests were used to assess group differences for categorical variables due to the relatively small participant group size.

3. Results

3.1. Participant characteristics

The average age of the participants ($N = 75$) was 41.3 ($SD = 12.1$) years old (range 17–62). There were 43 (57%) men and 32 (43%) women. Most participants were White British ($n = 64$, 85%) and

unemployed ($n = 59$, 79%), with 64 (85%) people working zero hours per week and the remaining 11 people working an average of 26.1 h per week ($SD = 12.3$, range = 5–40). Participant diagnoses included schizophrenia ($n = 49$, 65%), schizoaffective disorder ($n = 11$, 15%), psychosis NOS ($n = 11$, 15%) and delusional disorder ($n = 3$, 4%). Almost all the participants were outpatients ($n = 74$, 99%). Participant BMI ranged from 19.8 to 47.3 (mean = 30.2, $SD = 6.47$). Of the 74 participants for whom we had BMI data, 18 (24%) individuals were in the "healthy weight" range, 21 (28%) individuals were in the "over-weight" range, and 35 (47%) individuals were in the "obese category" range.

3.2. Activity descriptives

The mean step count across all the participants was 7127.5 ($SD = 5283.3$) steps per day, with a range from 890 to 30368. Step count as a measure of activity correlated with measures of meaningful activity ($r = 0.443$, $p < 0.001$) and mobility ($r = -0.321$, $p = 0.005$). Meaningful activity, as measured by the time budget, was low at a mean of 55.0 ($SD = 14.9$) (range = 22–98). Considering the group as a whole, mobility, as measured by the EQ5D mobility item, was somewhat impaired with a mean of 1.88 out of 5 ($SD = 1.08$) and a median of 1.

3.3. Physical activity profiles

LPA identified the best fitting solution as a three profile model with equal residual variances and covariances constrained to zero (BIC = 613.0) (see supplementary materials). The bootstrapped likelihood ratio test (BLRT) showed that the three profile model was a significantly better fit to the data than two profiles ($p = 0.01$), whereas the addition of a fourth did not improve model fit ($p = 0.95$). The entropy value of 0.95 indicated a high level of classification certainty with this solution, with the latent class probabilities for most likely profile membership ranging from 0.96 to 0.99.

The raw scores for the physical activity variables across the three profiles are shown in Table 1 and standardised values are visualised in Fig. 1. To aid visualisation of the profiles, the mobility score was recoded in the direction of the other physical activity measures so that a lower score indicated worse mobility. The most prevalent profile, 'low activity but mobile', included 63% ($n = 47$) of the total participant group and was characterised by a low step count, low levels of meaningful activity, and few mobility problems (male = 26, female = 21, mean age = 41.32, $SD = 12.08$). The second profile, 'immobile and low activity', was characterised by a low step count, low meaningful activity, and greater mobility problems, and included 27% ($n = 20$) of the participant group (male = 13, female = 7, mean age = 46.20, $SD = 10.86$). The smallest of the three profiles, 'active and mobile', included only 11% ($n = 8$) of the participant group and was characterised by high step count, high levels of meaningful activity, and few mobility problems (male = 4, female = 4, mean age = 43.38, $SD = 11.26$).

Table 1

Descriptive data for physical activity variables used to estimate the physical activity profiles.

	Step count	Meaningful activity	Mobility issues
Total sample ($N = 75$)			
Mean (SD)	7127.48 (5283.35)	54.96 (14.91)	1.88 (1.08)
Range	890–30368	22–98	1–5
Mobile but low activity ($n = 47$)			
Mean (SD)	6453.04 (3348.40)	53.15 (12.64)	1.30 (0.46)
Range	1360–14536	22–81	1–2
Immobile and low activity ($n = 20$)			
Mean (SD)	4205.10 (2442.05)	49.25 (10.33)	3.45 (0.60)
Range	890–9945	29–74	3–5
Mobile and active ($n = 8$)			
Mean (SD)	18395.75 (5714.56)	79.88 (13.68)	1.38 (0.52)
Range	11777–30368	66–98	1–2

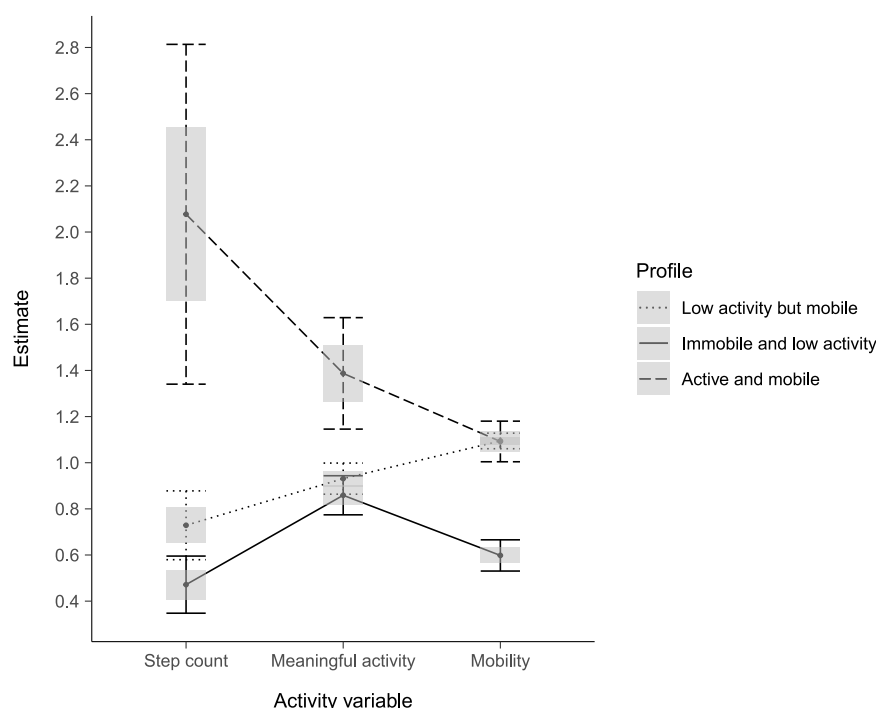


Fig. 1. Visualisation of the standardised estimates of each activity variable for the three profiles. For each profile, connected points represent the mean value, grey boxes represent the standard deviation, and the error bars represent 95% confidence intervals.

3.4. Differences between profiles

Descriptive scores and group differences between the three profiles are shown in Table 2. Participants in the three profiles did not differ significantly in age, gender, or employment status. However, there was a trend for a group effect that approached significance for number of hours worked, with the active and mobile group working more hours than both the low activity but mobile group and the immobile and low activity group, who, on average, worked zero hours. There was also a trend approaching significance for a group effect for BMI due to higher scores in the immobile and low activity profile compared to the two mobile profiles.

As summarised in Table 2, there was a significant group effect on the number of physical health hospital outpatient appointments in the past six months, with the immobile and low activity group having a greater number than the low activity but mobile (mean difference = 1.81, 95% CI = [0.20, 3.41], $p = 0.023$) and active and mobile (mean difference = 2.08, 95% CI = [-0.43, 4.58], $p = 0.124$) groups. Although the largest difference in hospital outpatient appointments was with the active and mobile group, this comparison was non-significant, mostly likely due to the small sample size in the latter group. The immobile and low activity group also had a somewhat higher number of GP appointments in the past months than the two mobile groups, but this effect was not significant. Although no group effect of medication dose was observed, it was notable that participants in the active and mobile profile were taking slightly smaller doses of antipsychotic medication which were, on average, less than the defined daily dose (DDD) of 1 and a maximum of only 1.5 times this standardised amount. Conversely, participants in the two low activity groups were taking more than the DDD on average and had a maximum dose of more than three times the standardised dose.

As shown in Table 2, depression levels were high across the whole participant group and there was a significant effect of activity profile on depression levels, with participants in the immobile and low activity group displaying higher depression scores than the low activity but mobile (mean difference = 10.10, 95% CI = [2.59, 17.6], $p = 0.005$) and the active and mobile (mean difference = -8.48, 95% CI = [-20.2,

3.30], $p = 0.204$) groups; the latter post-hoc comparison did not reach significance, however, likely due to a lack of power.

There was a trend approaching significance for a group effect of activity profile on levels of worry, with participants in the active and mobile group showing higher worry scores than the two other groups. The difference in frequency of hallucinations between the three profiles also approached significance, with the immobile and low activity group reporting more frequent hallucinations than both mobile groups. No other group effects were found, with similar levels of paranoia (ideas of persecution and social reference), anhedonia, insomnia, negative self-beliefs, negative other beliefs, safety-seeking behaviours, and psychological wellbeing across the three activity profiles.

4. Discussion

This study provides the first presentation of physical activity assessed by step count for people with persecutory delusions in the context of non-affective psychosis. Importantly, the study identifies three distinct activity profiles. The majority of participants were showing low levels of activity, but with a distinction between individuals who reported having mobility problems compared to those who did not. Being less active and immobile was generally associated with a poorer mental and physical health profile. It is plausible that members of the low activity and immobile profile group may face somewhat different barriers to activity than those in the low activity and mobile profile. The average step count of the total patient group was inflated by a small sub-group who had a very high step count. This sub-group shows that high physical activity is possible in the context of persecutory delusions, while there was an intriguing indication that this group has high levels of worry, arguably reflecting a failure to benefit fully from greater physical activity. These profile distinctions may prove helpful in the development of treatments to improve physical activity levels in people with psychosis, for example tailoring interventions for those with perceived mobility issues to address the poor mobility itself but also to take account of and intervene with the depression – as has been achieved with older adults who have mobility issues (Yeom, Keller, & Fleury, 2009). Virtual reality exercise

Table 2
Descriptive variables for total sample and each physical activity profile.

	Low activity but mobile	Immobile and low activity	Active and mobile	Test of group effect	
	n	n	n	p	
Employed/in education	9 (19%)	1 (5%)	3 (37.5%)	0.093	
	Mean (SD)	Mean (SD)	Mean (SD)	F (2,72)	p
Age	41.32 (12.08)	46.20 (10.86)	43.38 (11.26)	1.23	0.298
BMI	29.16 (5.92)	33.17 (7.30)	28.66 (5.61)	3.09	0.052
Hours worked	4.38 (11.0)	0.00 (0.00)	10.2 (15.5)	3.12	0.050
Antipsychotic medication dose	1.43 (0.70)	1.28 (0.83)	0.87 (0.46)	2.10	0.131
GP appointments	2.72 (3.15)	4.60 (5.35)	2.25 (1.83)	2.00	0.143
Physical health hospital appointments	0.89 (2.02) ^a	2.70 (3.67) ^b	0.63 (0.74)	4.02	0.022
Paranoia – persecution	26.51 (9.07)	28.15 (7.09)	33.63 (7.19)	2.48	0.091
Paranoia – reference	16.47 (8.41)	18.50 (6.41)	20.50 (9.94)	1.08	0.345
Hallucinations	20.64 (14.85)	29.95 (14.07)	23.88 (13.46)	2.89	0.062
Anhedonia	28.53 (12.05)	30.10 (12.03)	31.75 (14.54)	0.29	0.748
Depression	29.00 (13.07) ^a	39.10 (8.50) ^b	30.63 (10.18)	5.23	0.008
Wellbeing	35.49 (9.75)	31.50 (6.00)	36.63 (5.85)	1.78	0.176
Insomnia	14.98 (7.39)	15.47 (6.20)	15.25 (8.48)	0.03	0.968
Worry	62.70 (11.28)	66.50 (8.52)	71.63 (5.04)	3.09	0.052
Negative self	11.65 (6.12)	12.80 (4.88)	13.25 (4.33)	0.46	0.633
Negative other	13.55 (5.50)	14.75 (4.63)	16.38 (5.18)	1.15	0.322
Safety behaviours	34.89 (19.65)	39.90 (13.53)	39.13 (21.25)	0.60	0.554

Note: Significant group effects ($p < 0.05$) are highlighted in bold. Significant post-hoc differences between profiles ($p < 0.05$) are denoted by differing superscript letters.

games, involving physical activity, have also been shown to improve cognition and depression in older adults (Yen & Chiu, 2021). This could be a promising area for further research with individuals with persecutory beliefs.

The key limitation of this study was the relatively small participant group size, with small numbers particularly of participants who were highly active, so the findings only provide initial indications of distinct activity profiles and their correlates. Further research in larger participant group sizes will be needed. The cross-sectional design of this study also means that it is not possible to infer direction of the observed relationships, although it is likely that many are bidirectional. Though the study sought to measure physical activity objectively through a step count device, this may have nevertheless resulted in bias as the display of live step count when wearing the device could act as a motivator for increased activity. It has also been reported that the device used (Fitbit Charge) may systematically overestimate step count (Leininger, Cook, Jones, Bellumori, & Adams, 2016). Furthermore, objective information on daily wear time was unavailable. It is also acknowledged that mobility was only assessed using a single item, so further research examining mobility issues in this population is required. Despite these limitations, this study presents potentially important distinctions in activity profiles in people with persecutory delusions, which we believe

warrants attention. Improving physical activity levels in individuals with psychosis is rightly gaining increasing attention but our research indicates that there may be a need for tailoring interventions.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Data availability

The authors do not have permission to share data.

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