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Ecological monitoring of physical activity, emotions and daily life activities in schizophrenia: the DiAPAson study

Cristina Zarbo ,[1] Matteo Rota,[2] Stefano Calza,[2] Scott E Crouter,[3] Ulf Ekelund,[4,5] Stefano Barlati,[6] Riccardo Bussi,[7] Massimo Clerici,[8] Roberto Placenti,[9] Giuseppina Paulillo,[10] Silvia Pogliaghi,[11] Matteo Rocchetti,[12] Mirella Ruggeri,[13] Fabrizio Starace,[14] Stefano Zanolini,[15] Manuel Zamparini,[16] Giovanni de Girolamo ,[16] DiAPAson Collaborators

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For numbered affiliations see end of article.

Correspondence to
Dr Giovanni de Girolamo, UOPEV, IRCCS Centro San Giovanni di Dio Fatebenefratelli, Brescia, Italy; gdegirolamo@fatebenefratelli.eu

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ABSTRACT

Background Schizophrenia spectrum disorders (SSD) compromise psychosocial functioning, including daily time use, emotional expression and physical activity (PA).

Objective We performed a cohort study aimed at investigating: (1) the differences in PA, daily activities and emotions between patients with SSD and healthy controls (HC); (2) the strength of the association between these variables and clinical features among patients with SSD.

Methods Ninety-nine patients with SSD (53 residential patients, 46 outpatients) and 111 matched HC were assessed for several clinical variables, and levels of functioning by means of standardised clinical measures. Self-reported daily activities and emotions were assessed with a smartphone application for ecological momentary assessment (EMA), and PA levels were assessed with a wearable accelerometer for 7 consecutive days.

Findings

Patients with SSD, especially those living in residential facilities, spent more time being sedentary, and self-reported more sedentary and self-care activities, experiencing higher levels of negative emotions compared with HC. Moreover, higher functioning levels among patients were associated with more time spent in moderate-to-vigorous activity.

Conclusions Sedentary behaviour and negative emotions are particularly critical among patients with SSD and are associated with more impaired clinical outcomes.

Clinical implications Mobile-EMA and wearable sensors are useful for monitoring the daily life of patients with SSD and the level of PA. This population needs to be targeted with specific rehabilitative programmes aimed at improving their commitment to structured daily activities.

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BACKGROUND

Patients with schizophrenia spectrum disorders (SSD) often show marked impairments in daily time functioning,[1] with adverse consequences for prognosis, number of medical comorbidities and mortality rates.[2] However, despite the importance assigned to the daily time use of patients with SSD, most studies have mainly collected self-reported retrospective data. The use of retrospective self-reports in patients with severe mental disorders is prone to errors related to recall bias and to potentially impaired cognitive capacities.[3]

The integration of innovative methodologies (eg, ecological momentary assessment (EMA)) and wearable devices like accelerometer-based biosensors in research and clinical practice with individuals with SSD is promising. These tools reduce biases, provide longitudinal, objective and time-resolved ecologically valid data (ie, a fine-grained picture of patients' experiences in their natural contexts), and capture the variability over time and the dynamic patterns of reactivity to the environment.[4] In the last few decades, EMA has been used with patients with SSD for the evaluation of daily emotions or symptomatology, but only a few have used this methodology to assess daily life activities.[5–8] These studies have generally found that patients with SSD spend more than half (ie, 52%) of the day being inactive/doing nothing,[9] and most activities are performed sitting or lying down.[8] Furthermore, inactivity time is usually higher in patients with SSD when compared with healthy controls.[5 6]

Some studies have used accelerometer-based biosensors for the monitoring of physical activity (PA) in this population.[10–13] PA refers to any bodily movement that requires energy expenditure and engages the muscles. It encompasses a wide range of activities, such as walking, running, cycling, swimming, dancing, playing sports and engaging in structured exercise routines.[14] On the contrary, sedentary behaviour refers to activities involving low energy expenditure characterised by sitting, reclining or lying down while engaging in activities such as watching television, working on a computer, using electronic devices or reading.[15] A recent meta-analysis found that individuals with SSD spend a mean of 80.4 min in light PA, 47.1 min in moderate-to-vigorous PA (MVPA) and 1.05 min in vigorous PA per day[1] and usually show lower MVPA levels compared with healthy controls.[1 12] Moreover, lower PA and sedentary behaviour are

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Previous studies in this area have generally found that patients with schizophrenia spectrum disorders (SSD) spend a substantial proportion of daily time, often exceeding 50%, being sedentary and doing very few activities.
⇒ Some studies have used accelerometer-based biosensors as valid methodologies for the assessment and monitoring of physical activity (PA) outcomes in this population, and have shown that patients with SSD have reduced levels of PA.

WHAT THIS STUDY ADDS

⇒ Previous studies have never concurrently investigated differences in PA, daily time use and emotions between patients with SSD living in different treatment settings (outpatient and residential settings) and in comparison with healthy individuals.
⇒ We found that patients with SSD had lower PA levels compared with healthy controls, and these levels were associated with clinically relevant psychiatric outcomes.
⇒ We found the patients with SSD spend less time in working activities and experience more negative emotions than healthy controls.
⇒ We also found relevant differences in daily time use, PA and emotions between outpatients and residential patients, and this highlights the importance of treatment setting when evaluating the daily life of people with severe mental disorders.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Given the demonstrated relationship between sedentariness and a variety of physical comorbidities, the use of wearable biosensors and EMA to obtain a fine-grained picture of patients' daily life may be feasible in ordinary clinical practice and improve our multidimensional assessment of patients' lives.
⇒ Moreover, programmes implemented in residential facilities should be more intensive and make sure that patients spend more time engaged in a variety of activities.

associated with greater severity of positive symptoms, worse cognitive functioning, illness chronicity, higher antipsychotic dose and poorer quality of life, higher medical comorbidities and increased mortality rates.[2 16]

However, very few studies have monitored patients with SSD with both EMA and wearable accelerometers.[10 17 18] Only two of them, with very small samples, have investigated the association between ecological indexes and psychiatric functioning and severity[10 18] and, to the best of our knowledge, no studies have included healthy control participants. More importantly, none of them has considered the treatment setting (ie, residential facilities (RFs) or ambulatory), which is likely to influence both PA and daily activities (eg, in RFs, the presence of a structured day schedule, the continuous interaction with health workers, the joint management of the facilities for cleaning, cooking, etc, may solicit a more intensive daily activity regime).

OBJECTIVES

In the '*DAily time use, Physical Activity, quality of care and interpersonal relationships in patients with Schizophrenia spectrum disorders*' (DiAPAson) project,[19] we have studied different topics, including the quality of RFs in Italy,[20] the associations between time perspective, daily time use and levels of functioning among patients with SSD,[21] the prescription of antipsychotic medications and its relationship with PA,[22] the care needs of patients with SSD and its association with daily activities and mood monitored using the EMA,[23] the sleep-wake patterns[24], and the adherence rate to EMA and accelerometer[25 26] and predictors of EMA adherence.[26]

The aims of this paper were: (1) to identify possible differences in the amount of PA levels, the frequency of daily activities and the intensity of emotions between residential patients and outpatients with SSD, and healthy controls; and (2) to examine the magnitude of the associations between psychiatric severity/levels of functioning and PA levels, daily activities and emotions in patients with SSD, controlling for age, number of antipsychotic medications, disability level, number of cigarettes and season of measurement. We hypothesised that patients with SSD living in RFs would do more PA (assessed with accelerometer) and would do more self-reported working activities than outpatients, since they live in a highly structured environment and are continuously under staff supervision. We also hypothesised that all patients with SSD, regardless of the treatment setting, would report more negative emotions, as assessed with EMA, than healthy controls. Finally, we expected that more impaired daily functioning would be associated with poorer clinical outcomes.

METHODS

Study setting

This cohort study was conducted in a subsample of sites involved in the Italian national DiAPAson project[19]: these include seven Departments of Mental Health (DMHs), one clinical research centre (IRCCS) and two RFs. DMHs recruited both outpatients and residential patients, while RFs only recruited residential patients.

Eligibility criteria and recruitment

From October 2020 to October 2021, 137 eligible patients (79 residential patients, 58 outpatients) and 113 healthy controls (matched for age and sex) were initially recruited at the 10 participating centres for ecological monitoring. Inclusion and exclusion criteria are reported in online supplemental materials. Online supplemental figure 1S shows in detail the sampling selection process. To ensure a balanced comparison, healthy controls were sampled using a combination of public advertisements and snowball sampling techniques and matched with the clinical sample based on sex and age group, defined as: 20–24, 25–29, 30–34, 35–39, 40–44, 45–49 and 50–55 years of age. Sample size calculation has been thoroughly described in the study protocol.[19]

Outpatients were community-dwelling patients with SSD who were approached consecutively at the outpatient units for potential participation until the recruitment target was achieved. Residential patients were recruited by means of an alphabetical list of patients with SSD present on an index-day; based on this list, residential patients were consecutively invited to participate in the study.

Participants were provided with detailed information about the study and had an opportunity to ask questions. Some of the assessment tools were completed by the treating clinician, while research assistants (RAs) helped the participants complete self-reported questionnaires if needed. Standardised clinical measures were used to collect clinical data to minimise methodological biases (see section "Measures"). The ecological monitoring was preceded by a briefing session in which the RA gave instructions about the procedures and how to effectively perform them, and was followed by a debriefing section in which the same RA collected information on study acceptability and feasibility.[25]

Table 1 Sociodemographic characteristics of residential patients, outpatients and healthy controls

Variables	Residential patients n=53 (25%)	Outpatients n=46 (22%)	Controls n=111 (53%)	P value	Residential versus outpatients	Residential versus controls	Outpatients versus controls
Sex, n (%)				0.4	0.9	0.9	0.9
Female	16 (30%)	19 (41%)	44 (40%)				
Male	37 (70%)	27 (59%)	67 (60%)				
Age (years), n (%)				0.3	0.3	0.7	0.4
20–30	8 (15%)	12 (26%)	18 (16%)				
31–42	14 (26%)	17 (37%)	36 (32%)				
>43	31 (58%)	17 (37%)	57 (51%)				
Marital status, n (%)				<0.001	>0.9	0.001	0.001
Single	43 (81%)	39 (85%)	27 (24%)				
Married/Cohabiting	5 (9.4%)	3 (6.5%)	77 (69%)				
Divorced/Widowed	5 (9.4%)	4 (8.7%)	7 (6.3%)				
Education years				<0.001	0.4	<0.001	<0.001
Mean (SD)	11.9 (3.6)	12.5 (2.4)	16.6 (4.9)				
Median (minimum-maximum)	12.0 (7.0–21.0)	13.0 (8.0–18.0)	17.0 (6.0–27.0)				
Working status, n (%)				<0.001	0.001	0.001	0.001
Working	8 (15%)	24 (52%)	102 (92%)				
Studying	3 (5.7%)	6 (13%)	8 (7.2%)				
Not working	42 (79%)	16 (35%)	1 (0.9%)				
Charlson Comorbidity Index				<0.001	<0.001	<0.001	0.2
Mean (SD)	1.2 (1.6)	0.3 (0.7)	0.5 (0.8)				
Median (minimum-maximum)	1.0 (0.0–8.0)	0.0 (0.0–3.0)	0.0 (0.0–4.0)				
Weight (kg)				<0.001	0.009	0.13	<0.001
Mean (SD)	77.0 (16.3)	85.9 (22.0)	72.7 (14.6)				
Median (minimum-maximum)	76.0 (52.3–19.0)	85.0 (42.0–150.0)	71.0 (44.0–15.0)				
Body mass index				<0.001	<0.001	0.11	<0.001
Mean (SD)	25.4 (4.6)	29.3 (6.5)	24.2 (3.8)				
Median (minimum-maximum)	24.9 (17.7–36.9)	28.5 (16.7–44.8)	23.9 (17.7–35.5)				
Smoking (cigarettes/day)				<0.001	0.6	<0.001	<0.001
Mean (SD)	17.3 (8.2)	18.4 (9.9)	8.9 (6.0)				
Median (minimum-maximum)	20.0 (1.0–40.0)	15.0 (5.0–40.0)	10.0 (0.3–22.0)				
(Missing)	19	28	90				

During the debriefing session, outpatients and healthy controls received €25 for travel expense reimbursement.

MEASURES

Sociodemographic, physical and clinical assessments

For each recruited participant, sociodemographic details (see table 1 for a list) were gathered. Psychiatric history of patients was assessed using a structured ad hoc survey aimed at collecting information on the current diagnosis, illness duration and lifetime duration of psychiatric hospitalisations. The Charlson Comorbidity Index[27] was used for the assessment of physical comorbidities of participants. The 24-item Brief Psychiatric Rating Scale (BPRS)[28] was used to assess psychopathology. Negative symptoms severity was assessed with the Brief Negative Symptom Scale (BNSS).[29] The 43-item Specific Levels of Functioning Scale (SLOF)[30] was used for the assessment of levels of functioning. The WHO Disability Assessment Schedule 2.0 (WHODAS 2.0) was used for the assessment of disability level.

Assessment of daily time use and emotions

Self-reported daily time use (i.e., daily activities) and emotions were prospectively assessed with a brief questionnaire on a smartphone-based application for EMA, developed ad hoc for the project. The mobile application included three sections: current activities, social contacts and emotions. EMA emotions were chosen from an official 'Experience Sampling Method Item Repository' (https://osf.io/kg376/), which provides detailed info (including psychometric information) about all items used in different EMA studies. Notifications occurred 8 times a day, from 08:00 a.m. to 12:00 p.m., for seven consecutive days. Details about the EMA study are provided in the online supplemental tables 1S and 7S.

Assessment of physical activity and data processing

PA was monitored using the wearable accelerometer-based biosensor ActiGraph GT9X Link (https://theactigraph.com/). The ActiGraph was worn on the non-dominant wrist for seven consecutive days (the same days for the EMA monitoring). See online supplemental materials for detailed information on ActiGraph's data processing.

Statistical analyses

Data were summarised using mean and SD, median and IQR for quantitative variables, counts and percentages for qualitative ones.

Comparisons of sociodemographic and clinical variables across residential patients, outpatients and control participants were carried out through the χ^2 test for categorical variables and the analysis of variance test for continuous variables..

Table 2 Clinical characteristics of residential patients and outpatients

Variables	Residential patients n=53 (54%)	Outpatients n=46 (46%)	P value
Illness duration			0.017
Mean (SD)	19.9 (10.8)	15.0 (8.9)	
Median (minimum; maximum)	21.0 (1.0; 40.0)	13.0 (1.0; 34.0)	
Lifetime duration of psychiatric hospitalisation (years), n (%)			<0.001
<1	10 (19%)	43 (93%)	
1–5	20 (38%)	1 (2.2%)	
>5	23 (43%)	2 (4.3%)	
Mini Mental State Examination			0.13
Mean (SD)	27.4 (1.5)	27.8 (1.1)	
Median (minimum; maximum)	27.9 (24.2; 30.0)	28.1 (24.9; 29.0)	
Brief Psychiatric Rating Scale			0.001
Mean (SD)	48.6 (13.3)	40.9 (9.6)	
Median (minimum; maximum)	47.0 (27.0; 78.0)	40.0 (26.0; 70.0)	
Brief Negative Symptom Scale			0.011
Mean (SD)	24.2 (15.2)	16.8 (13.1)	
Median (minimum; maximum)	23.0 (0.0; 55.0)	14.0 (0.0; 54.0)	
Specific Levels of Functioning Scale			<0.001
Mean (SD)	174.4 (21.3)	193.4 (14.6)	
Median (minimum; maximum)	174.0 (125.0; 212.0)	195.0 (155.0; 215.0)	
(Missing)	0	2	
WHO Disability Assessment Schedule 2.0			0.6
Mean (SD)	10.6 (7.5)	9.8 (7.8)	
Median (minimum; maximum)	10.0 (0.0; 29.0)	9.0 (0.0; 29.0)	
(Missing)	0	1	
Antipsychotic (AP) drugs			<0.001
Mean (SD)	2.7 (1.3)	1.8 (1.0)	
Median (minimum; maximum)	3.0 (1.0; 6.0)	2.0 (0.0; 4.0)	
Non-APs drugs			0.12
Mean (SD)	0.8 (0.8)	0.5 (0.6)	
Median (minimum; maximum)	1.0 (0.0; 3.0)	0.5 (0.0; 2.0)	

The 15 daily time use categories were first grouped into 6 categories as follows: sedentary activities (staying sick in bed, thinking, resting and doing nothing), working activities (studying/attending training courses, cleaning, cooking, tidying up the house or car, shopping, taking care of someone or something and voluntary work), leisure activities (hobbies, watching TV or listening to the radio), PA (doing sports or PA/walking), self-care (self-caring and eating/drinking/having breakfast or snack) and religious activities. Then, data on daily time use were synthesised in terms of the daily average number of times each activity was done and compared across the three groups through a Generalised Linear Mixed Model with Poisson distribution after adjusting for smoking and seasonality. Results were reported in terms of rate ratios (RRs) with their 95% CIs.

Positive and negative emotions were computed by averaging positive (happy, relaxed, quiet and full of energy) and negative (sad, tired and nervous) emotions, respectively, and synthesised in terms of the daily average of positive and negative emotions on a 0–100 scale. Similar to daily time use, emotions ratings were compared across participant groups through a Linear Mixed Model with a random intercept (patient) after adjusting for smoke and seasonality. Results were reported in terms of estimated mean differences with corresponding 95% CIs.

Table 3 Between-group differences for self-reported daily activities and emotions assessed with EMA*

Activity	Residential patients n=53	Outpatients n=46	Healthy controls n=111	Residential patients/ Outpatients		Residential patients/Healthy controls		Outpatients/Healthy controls	
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Rate ratio (95% CI)	P value	Rate ratio (95% CI)	P value	Rate ratio (95% CI)	P value
Sedentary activities	1.23 (0.90 to 1.68)	0.88 (0.61 to 1.26)	0.49 (0.34 to 0.71)	1.40 (0.89 to 2.19)	0.186	2.50 (1.47 to 4.23)	<0.001	1.78 (1.00 to 3.17)	0.048
Working activities	0.67 (0.46 to 0.96)	1.62 (1.09 to 2.42)	2.68 (1.85 to 3.88)	0.41 (0.23 to 0.73)	<0.001	0.25 (0.13 to 0.46)	<0.001	0.61 (0.32 to 1.15)	0.16
Leisure activities	1.24 (0.90 to 1.72)	1.95 (1.36 to 2.81)	1.63 (1.15 to 2.30)	0.64 (0.38 to 1.05)	0.086	0.76 (0.44 to 1.33)	0.487	1.20 (0.67 to 2.16)	0.749
Physical activities	0.02 (0.01 to 0.10)	0.03 (0.01 to 0.12)	0.02 (0.01 to 0.09)	0.84 (0.14 to 5.14)	0.97	1.06 (0.15 to 7.65)	1.00	1.26 (0.16 to 9.75)	0.96
Self-care	1.85 (1.47 to 2.33)	1.31 (1.00 to 1.73)	1.14 (0.88 to 1.47)	1.41 (0.98 to 2.03)	0.064	1.63 (1.09 to 2.43)	0.012	1.15 (0.75 to 1.78)	0.720
Religious activities	0.01 (0.00 to 0.27)	0.00 (0.00 to 0.10)	0.00 (0.00 to Infinity)	2.73 (0.12 to 61.06)	0.73	3312442529.41 (0.00 to Inf)	1.00	1213328517.65 (0.00 to Inf)	1.00
Positive emotions	62.06 (57.85 to 66.27)	60.29 (55.78 to 64.81)	60.12 (57.21 to 63.02)	1.77 (−5.61 to 9.15)	0.84	1.94 (−4.17 to 8.06)	0.74	0.17 (−6.25 to 6.60)	1.00
Negative emotions	30.73 (27.32 to 34.15)	24.61 (20.95 to 28.28)	23.36 (21.00 to 25.71)	6.12 (0.13 to 12.11)	0.0439	7.38 (2.42 to 12.34)	0.0015	1.26 (−3.95 to 6.47)	0.8383

*Models were adjusted for number of cigarettes and season of measurement.
EMA, ecological momentary assessment.

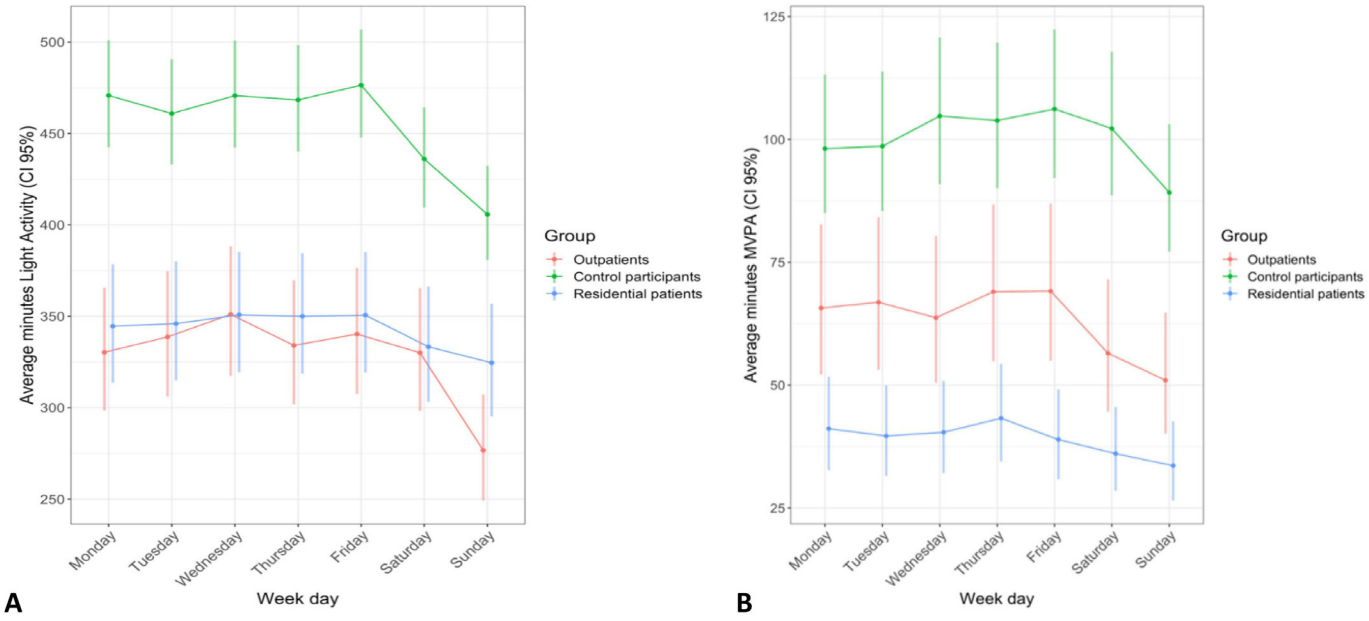

Figure 1 Light physical activity (A) and moderate-to-vigorous PA (MVPA) (B) pattern in the three groups during a week.

Additional details about statistical analyses can be found in the online supplemental file. All analyses were performed with R V.4.3.0.

FINDINGS

The final sample included 53 residential patients, 46 outpatients and 111 healthy controls who replied to at least 70% of the EMA notifications and who wore the accelerometer for at least 10 hours for 4 valid days (see online supplemental figure 1S for more details on sampling selection).

Sociodemographic and clinical characteristics

Table 1 shows the main sociodemographic characteristics of the three groups. Table 2 shows the clinical characteristics of the patients' sample. When compared with outpatients, residential patients reported significantly higher illness duration (p=0.017), lifetime duration of psychiatric hospitalisation (p<0.001), BPRS score (p<0.001), BNSS score (p=0.011) and lower levels of functioning (p<0.001); they also received a significantly higher mean number of antipsychotic medications (p<0.001).

Between-group differences in self-reported daily activities

The three groups significantly differed in daily time spent in sedentary activities, working activities and self-care activities (table 3), even controlling for the number of cigarettes per day and season. Indeed, residential patients were significantly less engaged in working activities when compared with both outpatients (RR 0.41 (95% CI 0.23 to 0.73); p<0.001) and healthy controls (RR 0.25 (95% CI 0.13 to 0.46); p<0.001). In addition, healthy controls were significantly less engaged in sedentary activities when compared with both outpatients (RR 1.78 (95% CI 1.00 to 3.17); p= 0.048) and residential patients (2.50 (95% CI 1.47 to 4.23); p<0.001). Finally, residential patients spent more time in self-care activities than healthy controls (RR 1.63 (95% CI 1.09 to 2.43); p=0.0014). No differences were found between residential patients and outpatients regarding time spent in sedentary activities, working activities and self-care activities. See online supplemental table 6S for details about the differences in the 15 daily activities between the 3 groups.

Between-group differences for self-reported emotions ratings

Controlling for the number of cigarettes per day and season, we found no differences in average ratings of positive emotions between the three groups, while residential patients showed a higher negative emotions intensity when compared with both outpatients (mean difference 6.12 points (95% CI 0.13 to 12.11); p=0.04) and healthy controls (mean difference 7.38 points (95% CI 2.42 to 12.34); p=0.0015). Outpatients and healthy controls did not differ in terms of negative emotions intensity (table 3).

Between-group differences for device-measured physical activity and sedentary behaviour

The three groups significantly differed for all activity levels (both min/day and %) (figure 1 and online supplemental table 3S and figure 2S), with healthy controls showing higher PA levels than the two patient groups, even controlling for daily % of wearing time, the number of cigarettes per day and season. Time spent in different PA levels are expressed in mean min/day.

Sedentary time was significantly higher in residential patients compared with both outpatients and healthy controls (respectively RR 1.16 (95% CI 1.10 to 1.23); p<0.001); RR 1.15 (95% CI 1.15 to 1.28); p<0.001). Outpatients and healthy controls did not differ from each other for time spent sedentary (RR 1.04 (95% CI 0.99 to 1.10); p=0.10). When expressed in relative terms, the sedentary time represented 48%–51% of total wake time in patient groups, which was also a significantly larger fraction compared with healthy controls (i.e., 40%).

MVPA was significantly higher in healthy controls (91.3 mean min/day) than in both outpatients (64.1 mean min/day) and residential patients (44.6 mean min/day). Outpatients spent a significantly larger fraction of time doing MVPA per day compared with residential patients (RR 0.70 (95% CI 0.53 to 0.92); p= 0.01) and lower time when compared with healthy controls (RR 0.70 (95% CI 0.55 to 0.90); p= 0.004).

Online supplemental tables 4S and 5S show the comparison of activity levels (both min/day and %) in the three groups divided respectively by weekdays and weekends. The findings remained stable even after checking for weekdays/weekends separately,

Table 4 Relationships between ecological indexes and clinical outcomes in patients with SSD*

	BPRS	BNSS	SLOF
Variables assessed with actigraph			
METs	3.5411 (−11.8446 to 5.0528)	2.8353 (-13.7123 to 8.5072)	7.1038 (−5.3459 to 19.7699)
Sedentary PA (60 min/day*)	0.2862 (−0.8116 to 1.4887)	0.1747 (−1.5613 to 1.3363)	0.5532 (−2.125 to 1.1853)
Light PA (60 min/day*)	0.4726 (−0.6727 to 1.6214)	0.2356 (−1.7438 to 2.0058)	1.7642 (−3.8915 to 0.2182)
MVPA (60 min/day*)	1.5889 (−5.7372 to 1.2438)	1.5889 (−5.7372 to 1.2438)	1.5889 (−5.7372 to 1.2438)
Sedentary PA (%)	0.0195 (−0.1282 to 0.1873)	0.0096 (−0.197 to 0.2105)	0.0031 (−0.2503 to 0.2629)
Light PA (%)	0.0468 (−0.1549 to 0.2533)	0.0611 (−0.2267 to 0.3325)	0.1941 (−0.4951 to 0.1589)
MVPA (%)	0.2865 (−0.6719 to 0.063)	0.2827 (−0.6986 to 0.1259)	0.7159 (0.1489 to 1.2729)
Variables assessed with EMA			
Sedentary activities	0.162 (−2.529 to 2.132)	2.2768 (−0.3225 to 4.91)	3.5702 (−7.9509 to 0.9373)
Working activities	0.0666 (−4.5877 to 0.9239)	0.3838 (−5.3427 to 0.6396)	0.9132 (−2.7 to 8.1434)
Leisure activities	2.0763 (0.6451 to 3.3313)	1.7299 (−0.1926 to 3.3613)	4.0101 (−6.3116 to −0.8023)
Physical activities	3.1205 (−9.5155 to 6.9202)	1.7175 (−10.176 to 8.9945)	11.4208 (−17.3502 to 14.4894)
Self-care	1.7003 (−0.4252 to 3.2716)	0.4271 (−2.0264 to 2.9407)	3.8346 (−7.3625 to 1.0411)
Religious activities	2.8225 (−8.3627 to 6.8976)	1.9917 (−6.9502 to 6.3228)	12.6462 (−20.7503 to 3.246)
Positive emotions	0.3683 (−1.3586 to 2.0843)	0.7589 (−2.66 to 1.1949)	0.1004 (−2.8699 to 3.4415)
Negative emotions	0.0792 (−0.0533 to 0.2057)	0.0285 (−0.1929 to 0.1046)	0.1181 (−0.343 to 0.1043)

*Controlling for age, medication, disability level, number of cigarettes and season of measurement.
BNSS, Brief Negative Symptoms Scale; BPRS, Brief Psychiatric Rating Scale; EMA, ecological momentary assessment; METs, Metabolic Equivalent of Tasks; MVPA, moderate-to-vigorous activity; PA, physical activity; SLOF, Specific Levels of Functioning Scale; SSD, schizophrenia spectrum disorders.

except for two results. First, we found a significant difference between outpatients and healthy controls in levels of sedentary time (RR 1.11 (95% CI 1.02 to 1.21); p=0.01) only during weekends. Second, the difference in MVPA levels found between residential patients and outpatients disappears if we look only at weekend days (RR 0.76 (95% CI 0.56 to 1.02); p=0.06).

Association between ecological indexes and clinical outcomes

Table 4 shows the results of the association between ecological indexes and clinical outcomes. MVPA was significantly associated only with the SLOF scale, with an increase of 4.95 points (95% CI 0.46 to 10.11) for 60 min/day of MVPA. The amount of self-reported time spent in leisure activities was significantly associated with an increase in the BPRS score (2.07, 95% CI 0.65 to 3.33) and a reduction in SLOF score (−4.01, 95% CI −6.31 to −0.80). No relationships were found between clinical outcomes and intensity of emotions.

DISCUSSION

This study found significant differences between the two groups of patients with SSD and healthy controls for PA levels, emotions intensity and daily time use. We also found a significant relationship between selected ecological indexes and levels of psychiatric severity/levels of functioning of individuals with SSD.

Daily time use

Compared with healthy individuals, patients (especially if living in RFs) were generally engaged for more time in sedentary activities and self-care activities and for a lesser time in working activities. Moreover, time spent in leisure activities was associated with higher psychiatric severity and lower levels of functioning. These results are in line with previous EMA studies which found higher self-reported inactivity time in patients with SSD when compared with healthy controls[5 6] and found an association between specific activities (i.e., work activities) and clinical outcomes (ie, hallucinations, self-rated health, mastery and quality of life).[31 32]

The marked differences in daily time use between patients with SSD and healthy controls are likely to be at least partly due to the severity and nature of psychiatric symptoms, particularly negative symptoms (eg, those that affect motivation, concentration, organisational and interpersonal skills). Negative symptoms are extremely difficult to treat and they can profoundly compromise the daily functioning of patients with SSD,[33] possibly leading to a large amount of time spent doing nothing. These differences may be also due to the higher proportion of patients not working/studying and with a single status, which may be in turn associated with a psychiatric history, lower psychosocial functioning and fewer relationships. In addition, residential patients showed more severe symptomatology and could also be more restricted on where and the types of activities they did, limiting the opportunity to do different activity types.

Daily emotions

Patients with SSD living in RFs reported higher intensity of negative emotions if compared with healthy controls; on the contrary, there were no differences in subjectively reported negative emotions between outpatients and healthy controls. The higher degree of negative emotions among residential patients was unrelated to their psychiatric symptoms or levels of functioning. This result is partially in line with a meta-analysis of 12 EMA studies,[34] showing that people with SSD consistently report both more negative and less positive emotions than healthy controls; however, in these studies treatment setting was rarely assessed, and was not one of the main variables to be considered. Characteristics of the living environments should be carefully considered whenever the quality of daily emotions is assessed.

Physical activity

Patient groups and healthy controls in this study appear to reach the minimum level of PA required to maintain health, that is, 23 min/day of MVPA.[35] However, when compared with healthy controls, patients with SSD spent more time in sedentary behaviour—as assessed by the accelerometer—and their PA levels were associated with levels of functioning, especially if living in RF.

Our results about residential patients are in line with findings of previous studies, which found that patients with SSD spend on average about 45 min/day engaged in MVPA,[1] or about 5% of the daytime.[36] However, in our study outpatients spent more time engaged in MVPA (i.e., about 64 min/day, 8.5%). This difference enforces the need to do independent analyses based on treatment setting when looking at PA levels of individuals with SSD. Moreover, our findings support studies that

found that individuals with SSD have lower PA levels compared with healthy controls and that these levels are associated with clinically relevant psychiatric outcomes (eg, severity of positive symptoms, illness chronicity, higher antipsychotic dose, depression and poorer quality of life).[1 12]

The differences in PA levels that we found between patients with SSD and healthy controls may be due to the association with a variety of clinical factors (eg, severe negative symptoms, medication side effects, cognitive and sensory impairments, lack of motivation and energy, cognitive overload, poor education as well as living conditions and environmental factors (eg, stigma and discrimination, lack of supportive social network, limited access to safe spaces, financial constraints, transportation barriers, lack of individualised programmes).[37] Addressing these environmental factors and providing targeted support, such as creating safe spaces, offering transportation assistance, providing financial support and designing inclusive and individualised exercise programmes, can help promote PA among individuals with SSD.

Limitations and strengths

The study was conducted during the COVID-19 pandemic, and this may have affected both the PA monitoring and the evaluation of daily time use and emotions. However, since the recruitment of patients and controls took place at the same time, this change is likely to have affected both study groups. Moreover, SSD diagnoses were based only on medical records because of financial and logistic limitations. The measurement of activity at the wrist usually overestimates PA and can hardly distinguish between sitting and standing. This may raise problems in defining sedentary behaviour, since all PA ≤1.5 MET was counted as sedentary behaviour without considering body position.

However, this is the first study that assessed PA, daily activities and emotions in patients with SSD in different treatment settings and compared them with healthy controls. This study was performed with a multimethod approach that integrated both self-reported and objective, longitudinal measures for the assessment of targeted ecological indexes. Finally, the involvement of 10 recruitment centres makes our findings and the generalisability of the conclusions stronger.

CLINICAL IMPLICATIONS

Rehabilitative programmes implemented in RFs for people with SSD should be improved: many people who live there spend a significant amount of time doing nothing. Staff should be better trained to plan and implement personalised programmes aimed at helping these patients more efficaciously. Programmes of social skills training, structured programmes of PA and interventions to facilitate contact with local communities should be carefully combined to stimulate patients with SSD and improve their subjective well-being and their physical health. The information collected in this study may represent a further step in this direction.

Author affiliations
[1]Department of Psychology, University of Milan-Bicocca, Milano, Italy
[2]Department of Molecular and Translational Medicine, University of Brescia, Brescia, Italy
[3]Department of Kinesiology, Recreation, and Sport Studies, The University of Tennessee Knoxville, Knoxville, Tennessee, USA
[4]Department of Chronic Diseases and Ageing, Norwegian Institute of Public Health, Oslo, Norway
[5]Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway
[6]Department of Clinical and Experimental Sciences, University of Brescia, Brescia, Italy
[7]Centro Sant'Ambrogio-Fatebenefratelli, Cernusco sul Naviglio, Italy
[8]Department of Medicine and Surgery, University of Milan-Bicocca, Monza, Italy
[9]Centro Sacro Cuore di Gesù Fatebenefratelli, San Colombano al Lambro, Italy
[10]Department of Mental Health and Pathological Addiction, Azienda USL di Parma, Parma, Italy
[11]Department of Neurosciences, Biomedicine and Movement Sciences, University of Verona, Verona, Italy
[12]Department of Mental Health, ASST di Pavia, Pavia, Italy
[13]Department of Psychiatry, Verona Hospital Trust, AOUI, Verona, Italy
[14]Department of Mental Health and Dependence, AUSL Modena, Modena, Italy
[15]Department of Mental Health and Dependence, Azienda ULSS 8 Berica, Vicenza, Italy
[16]Unit of Epidemiological and Evaluation Psychiatry, IRCCS Istituto Centro San Giovanni di Dio Fatebenefratelli, Brescia, Italy

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Collaborators DiAPAson Collaborators: Carlo Matteo Dentali (RF CREST, Vinago, Varese), Antonio de Novellis (DSMD, AUSL of Modena), Antonina Di Gregorio (DSMD, ASST Melegnano and Martesana, Melegnano), Vittorio Di Michele (DSM, ASL Pescara), Patricia Giosuè (DSM, ASL Teramo), Federico Facchini (DSM, ASL Città di Torino), Carmelo Greco (DSMD, ASST Cremona), Filippo M Jacoponi (RF Passaggi Srl-Oricola, Aquila), Emanuela Leuci (DSMD, AUSL Parma), Fabio Lucchi (DSM, APSS Trento, Rovereto), Daniela Malagamba (DSM, ASL 3 Genova), Emiliano Monzani (DSMD, ASST Bergamo Ovest), Marina Marina (RF Fondazione Giuseppe Costantino, Pavia), Alessandra Martinelli (IRCCS Fatebenefratelli, Brescia; Section of Psychiatry, Verona Hospital Trust, AOUI, Verona), Nicola Necchini (DSMD, ASST Spedali Civili, Brescia), Jessica Orticola (RF Progetto Du Parc, Torino), Rodolfo Pessina (DSMD, ASST Monza), Beatrice Rufelli (DSM, ASL Roma1), Arturo Rippa (DSM, ASUITS Trieste), Lorenzo Tatini (DSM, USL Toscana Centro, Prato), Giambattista Tura (IRCCS Fatebenefratelli, Brescia), Salvatore Zizolfi (RF CREST 'La Perla', Grumello del Monte, Bergamo).

Contributors CZ: conceptualisation; investigation; methodology; project administration; supervision; visualisation; writing—original draft; writing—review and editing. MR: data curation; formal analysis; methodology; software; visualisation; writing—original draft; writing—review and editing. SC: data curation; formal analysis; methodology; software; visualisation; writing—original draft; writing—review and editing. SEC, UE: conceptualisation; methodology; supervision; writing—review and editing. SB, RB, MC, RP, GP, MR, SZ: investigation; writing—review and editing. SP: conceptualisation; supervision; visualisation; writing—original draft; writing—review and editing. MR: methodology; project administration; supervision; writing—review and editing; funding acquisition. FS: methodology; project administration; supervision; writing—review and editing;

funding acquisition. MZ: conceptualisation; data curation; methodology; writing—review and editing. GdG: conceptualisation; methodology; supervision; visualisation; funding acquisition; writing—original draft; writing—review and editing.GdG is the responsible for the overall content of the manuscript.

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ORCID iDs
Cristina Zarbo http://orcid.org/0000-0002-6613-4445
Giovanni de Girolamo http://orcid.org/0000-0002-1611-8324

REFERENCES

1 Stubbs B, Firth J, Berry A, *et al*. How much physical activity do people with schizophrenia engage in? A systematic review, comparative meta-analysis and meta-regression. *Schizophr Res* 2016;176:431–40.
2 Ringen PA, Engh JA, Birkenaes AB, *et al*. Increased mortality in schizophrenia due to cardiovascular disease - a non-systematic review of epidemiology, possible causes, and interventions. *Front Psychiatry* 2014;5:137.
3 Oorschot M, Kwapil T, Delespaul P, *et al*. Momentary assessment research in psychosis. *Psychol Assess* 2009;21:498–505.
4 Myin-Germeys I, Oorschot M, Collip D, *et al*. Experience sampling research in psychopathology: opening the black box of daily life. *Psychol Med* 2009;39:1533–47.
5 Oorschot M, Lataster T, Thewissen V, *et al*. Symptomatic remission in psychosis and real-life functioning. *Br J Psychiatry* 2012;201:215–20.
6 Granholm E, Holden JL, Mikhael T, *et al*. What do people with schizophrenia do all day? ecological momentary assessment of real-world functioning in schizophrenia. *Schizophr Bull* 2020;46:242–51.
7 Jones SE, Moore RC, Depp CA, *et al*. Daily ecological momentary assessments of happy and sad moods in people with schizophrenia and bipolar disorders: what do participants who are never sad think about their activities and abilities *Schizophr Res Cogn* 2021;26:100202.
8 Strassnig MT, Harvey PD, Miller ML, *et al*. Real world sedentary behavior and activity levels in patients with schizophrenia and controls: an ecological momentary assessment study. *Ment Health Phys Act* 2021;20.
9 Granholm E, Loh C, Swendsen J. Feasibility and validity of computerized ecological momentary assessment in schizophrenia. *Schizophr Bull* 2008;34:507–14.
10 Kluge A, Kirschner M, Hager OM, *et al*. Combining Actigraphy, ecological momentary assessment and neuroimaging to study apathy in patients with schizophrenia. *Schizophr Res* 2018;195:176–82.
11 Janney CA, Ganguli R, Richardson CR, *et al*. Sedentary behavior and psychiatric symptoms in overweight and obese adults with schizophrenia and Schizoaffective disorders (WAIST study). *Schizophr Res* 2013;145:63–8.
12 Wee ZY, Yong SWL, Chew QH, *et al*. Actigraphy studies and clinical and Biobehavioural correlates in schizophrenia: a systematic review. *J Neural Transm (Vienna)* 2019;126:531–58.
13 Tahmasian M, Khazaie H, Golshani S, *et al*. Clinical application of Actigraphy in psychotic disorders: a systematic review. *Curr Psychiatry Rep* 2013;15:359.
14 World Health Organization. Physical activity. fact sheet. 2021.
15 World Health Organization. WHO guidelines on physical activity and sedentary behaviour. 2020.
16 Wildgust HJ, Hodgson R, Beary M. The paradox of premature mortality in schizophrenia: new research questions. *J Psychopharmacol* 2010;24:9–15.
17 Raugh IM, James SH, Gonzalez CM, *et al*. Digital Phenotyping adherence, feasibility, and tolerability in outpatients with schizophrenia. *J Psychiatr Res* 2021;138:436–43.
18 Mulligan LD, Haddock G, Emsley R, *et al*. High resolution examination of the role of sleep disturbance in predicting functioning and psychotic symptoms in schizophrenia: A novel experience sampling study. *J Abnorm Psychol* 2016;125:788–97.
19 de Girolamo G, Rocchetti M, Benzi IMA, *et al*. Daily time use, physical activity, quality of care and interpersonal relationships in patients with schizophrenia spectrum disorders (DIAPASON): an Italian Multicentre study. *BMC Psychiatry* 2020;20:287.
20 Martinelli A, Killaspy H, Zarbo C, *et al*. Quality of residential facilities in Italy: satisfaction and quality of life of residents with schizophrenia spectrum disorders. *BMC Psychiatry* 2022;22:717.
21 Zarbo C, Stolarski M, Zamparini M, *et al*. Time perspective affects daily time use and daily functioning in individuals with schizophrenia spectrum disorders: results from the Multicentric diapason study. *J Psychiatr Res* 2023;160:93–100.
22 Oliva V, Fanelli G, Zamparini M, *et al*. Patterns of antipsychotic prescription and accelerometer-based physical activity levels in people with schizophrenia spectrum disorders: a multicenter, prospective study. *Int Clin Psychopharmacol* 2023;38:28–39.
23 Martinelli A, D'Addazio M, Zamparini M, *et al*. Needs for care of residents with schizophrenia spectrum disorders and association with daily activities and mood monitored with experience sampling method: the DIAPASON study. *Epidemiol Psychiatr Sci* 2023;32:e18.
24 Mayeli A, LaGoy AD, Smagula SF, *et al*. Shared and distinct abnormalities in sleep-wake patterns and their relationship with the negative symptoms of schizophrenia spectrum disorder patients. *Mol Psychiatry* 2023;2023:1–9.
25 Zarbo C, Agosta S, Casiraghi L, *et al*. Assessing adherence to and usability of experience sampling method (ESM) and Actigraph in patients with schizophrenia spectrum disorder: A mixed-method study. *Psychiatry Res* 2022;314:S0165-1781(22)00275-X.
26 Zarbo C, Zamparini M, Nielssen O, *et al*. Comparing adherence to the experience sampling method among patients with schizophrenia spectrum disorder and unaffected individuals: observational study from the Multicentric diapason project. *J Med Internet Res* 2023;25:e42093.
27 Charlson ME, Pompei P, Ales KL, *et al*. A new method of classifying Prognostic Comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–83.
28 Morosini P, Casacchia M. Traduzione Italiana Della brief psychiatric rating scale, Versione 4.0 Ampliata (BPRS 4.0). *J Rivista Di Riabilitazione Psichiatrica e Psicosociale* 1995;3:199–228.
29 Merlotti E, Mucci A, Bucci P, *et al*. Italian version of the "brief negative symptom scale. *Journal of Psychopathology* 2014;20:199–215.
30 Montemagni C, Rocca P, Mucci A, *et al*. Italian version of the 'Specifc level of functioning. *J Psychopathol* 2015;1:287–96.
31 Leufstadius C, Erlandsson LK, Eklund M. Time use and daily activities in people with persistent mental illness. *Occup Ther Int* 2006;13:123–41.
32 Delespaul P, deVries M, van Os J. Determinants of occurrence and recovery from hallucinations in daily life. *Soc Psychiatry Psychiatr Epidemiol* 2002;37:97–104.
33 Fusar-Poli P, Papanastasiou E, Stahl D, *et al*. Treatments of negative symptoms in schizophrenia: meta-analysis of 168 randomized placebo-controlled trials. *Schizophrenia Bulletin* 2015;41:892–9.
34 Cho H, Gonzalez R, Lavaysse LM, *et al*. Do people with schizophrenia experience more negative emotion and less positive emotion in their daily lives? A meta-analysis of experience sampling studies. *Schizophrenia Research* 2017;183:49–55.
35 World Health Organization. WHO guidelines on physical activity and sedentary behaviour: web annex: evidence profiles. 2020. Available: https://www.who.int/publications/i/item/9789240015128
36 Pieters LE, Deenik J, Tenback DE, *et al*. Exploring the relationship between movement disorders and physical activity in patients with schizophrenia: an Actigraphy study. *Schizophr Bull* 2021;47:906–14.
37 Vancampfort D, De Hert M, De Herdt A, *et al*. Associations between physical activity and the built environment in patients with schizophrenia: a multi-centre study. *Gen Hosp Psychiatry* 2013;35:653–8.