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Motor activity patterns in acute schizophrenia and other psychotic disorders can be differentiated from bipolar mania and unipolar depression

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ABSTRACT

The purpose of this study was to compare 24-h motor activity patterns between and within three groups of acutely admitted inpatients with schizophrenia and psychotic disorders (n = 28), bipolar mania (n = 18) and motor-retarded unipolar depression (n = 25) and one group of non-hospitalized healthy individuals (n = 28). Motor activity was measured by wrist actigraphy, and analytical approaches using linear and non-linear variability and irregularity measures were undertaken. In between-group comparisons, the schizophrenia group showed more irregular activity patterns than depression cases and healthy individuals. The schizophrenia and mania cases were clinically similar with respect to high prevalence of psychotic symptoms. Although they could not be separated by a formal statistical test, the schizophrenia cases showed more normal amplitudes in morning to evening mean activity and activity variability. Schizophrenia constituted an independent entity in terms of motor activation that could be distinguished from the other diagnostic groups of psychotic and non-psychotic affective disorders. Despite limitations such as small subgroups, short recordings and confounding effects of medication/hospitalization, these results suggest that detailed temporal analysis of motor activity patterns can identify similarities and differences between prevalent functional psychiatric disorders. For this purpose, irregularity measures seem particularly useful to characterize psychotic symptoms and should be explored in larger samples with longer-term recordings, while searching for underlying mechanisms of motor activity disturbances.

1. Introduction

Disturbed motor activity is a frequently occurring symptom in psychotic disorders (APA, 2000; WHO, 1993). Motor behavior in schizophrenia is traditionally detected clinically through observation and rating scales, even though clinical evaluation in general and individual rating scale items in particular appear to correlate poorly with objective quantifications of movement (Walther et al., 2009c). If assessment of motor symptoms was made more comprehensive and reliable, specific motor characteristics related to psychosis could help distinguish subtypes within the schizophrenia spectrum and delineate the boundaries to other psychiatric illness categories (Hauge et al., 2011; Walther et al., 2009b).

Actigraphy is a validated approach to record movement as longitudinal rest-activity patterns (Ancoli-Israel et al., 2003). Most devices are wrist-worn and well-tolerated by patients in psychiatry. Relatively few studies have applied actigraphy to samples with schizophrenia and psychotic disorders, usually to assess sleep estimates or mean activity levels (Docx et al., 2013; Tahmasian et al., 2013; Wichniak et al., 2011). Actigraphy studies that consider motor activity patterns in more complex time series analyses do, however, seem to be more promising regarding correlation with specific symptom characteristics. These studies have predominantly come from one group in Switzerland (Walther et al., 2009a; Walther et al., 2009b; Walther et al., 2014; Walther et al., 2015), and our collaborators in Bergen, Norway (Berle et al., 2010; Fasmer et al., 2016; Hauge et al., 2011). This research shows that negative symptoms correlate with reduced activity and inversely, that less rest is common during marked positive

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syndromes (Walther et al., 2009b). In a group of patients with chronic psychosis, activity patterns were more variable and more irregular compared to healthy individuals, but in contrast, contained longer periods of inactivity and lower variability compared to depressed patients (Fasmer et al., 2016; Hauge et al., 2011).

In several publications on acutely ill inpatients with affective disorders, we have applied linear and nonlinear analytical methods to 24-h actigraphy recordings (Krane-Gartiser et al., 2015; Krane-Gartiser et al., 2014; Krane-Gartiser et al., 2016). For mania, we found irregular activity patterns that are stable within 24 h, whereas depressed subgroups demonstrated low total activity, higher variability between active and inactive periods and several changes in activity parameters within 24 h (Krane-Gartiser et al., 2014; Krane-Gartiser et al., 2017). As schizophrenia cases in other studies have shown motor features that resemble our findings for both mania and depression, the aim of the current study was two-fold: first, to characterize 24-h motor activity patterns in a new group of inpatients with schizophrenia and psychotic disorders, and second, to compare them to inpatients from the same setting with bipolar mania and motor-retarded unipolar depression and to a non-hospitalized group of healthy individuals. We hypothesized that cases with depression would have lower activity levels and more regular patterns compared to the other groups, and that cases with mania and schizophrenia would show similar features of irregularity in activity patterns. Because our application of linear and nonlinear dynamics in between-group comparisons as well as in within-group analyses from morning to evening has proven valuable, we wanted to undertake the same procedure for the group with schizophrenia and psychotic disorders.

2. Materials and methods

2.1. Sample

Inpatients were asked to participate in the study as they were consecutively admitted to Østmarka Department of Psychiatry, Trondheim University Hospital, Norway. This is the only department for acute psychiatric admissions in the catchment area, and all psychiatric emergency services in Norway are public. The only exclusion criterion was inability to grant informed consent. Patients were asked to wear an actigraph for 24 h on one of the first days after admission, and a total of 280 actigraphy recordings were undertaken between September 1st, 2011 and March 31st, 2012. Diagnoses were set in an expert consensus meeting according to ICD-10 research diagnostic criteria (WHO, 1993), by at least three specialists in psychiatry of whom one had been the patient's therapist and another personally knew the patient. The experts reviewed all available information when setting the diagnosis. Twenty-eight patients with a 24-h actigraphy recording had a primary diagnosis of schizophrenia and other psychotic disorders. Eighteen of them fulfilled the criteria for schizophrenia (13 paranoid schizophrenia (F20.0), 3 hebephrenic schizophrenia (F20.1), 1 simple schizophrenia (F20.6) and 1 schizophrenia unspecified (F20.9)), 2 patients had persistent delusional disorders (F22.0), 3 had acute and transient psychotic disorders (F23), 4 had schizoaffective disorders (F25) and 1 had an unspecified nonorganic psychosis (F29). Thus, 28 cases with schizophrenia spectrum disorders were compared to 18 inpatients with a primary diagnosis of bipolar disorder, current episode manic (7 patients without psychotic symptoms (F31.1) and 11 with psychotic symptoms (F31.2)) and 25 inpatients with unipolar depression (UP) and psychomotor retardation. UP cases with any observable motor retardation were classified as motor-retarded, as defined by the Symptomatic Organic Mental Disorder Assessment Scale, item B: “Degree of motor retardation, rated during the period or periods of the previous 24 h in which the patient was most depressed.” (Krane-Gartiser et al., 2015). Three of the patients with unipolar depression were in a mild depressive episode (F32.0 or F33.0), 15 in a moderate episode (F32.1 or F33.1) and 7 in a severe episode without psychotic symptoms (F32.2 or F33.2).

2.2. Recordings of motor activity

Motor activity was recorded by wrist-worn actigraphy (Actiwatch Spectrum, Philips Respironics Inc., Murrysville PA, USA). The actigraph integrates the intensity, amount and duration of wrist movement in all directions into an activity count per time unit. Patients and healthy controls were instructed to wear the actigraph continuously during 24 h, constituting 1440 min for analysis for complete recordings. Three cases from each patient-group had recordings with a duration < 22 h; the median recording was 1429 min (schizophrenia group), 1436 min (mania group) and 1439 min (UP group).

Activity counts were recorded for one-minute intervals (epochs). Data were analyzed for the total time of recording (24 h). For each case, we also selected morning and evening epochs by inspecting each recording for the first 64-min period of continuous activity in the morning after 6 AM and for the last 64-min period of continuous activity in the evening before midnight. 64 min were chosen because the Fourier analysis requires sequence lengths to be potencies of 2 (32, 64, 128…) and from previous experience, it can be difficult to find periods of continuous activity that are longer than one hour.

One patient from the schizophrenia/psychotic disorders group lacked a 64-min active sequence in the morning, as well as two patients with mania and two UP patients. These patients were omitted from morning series analyses, reducing the group with psychotic disorders to 27, the group with mania to 16 and the group with UP to 23 patients. One patient with a psychotic disorder, two UP patients and one healthy control lacked a 64-min active sequence in the evening. Thus, in the evening series analyses, 27 patients with psychotic disorders were compared to 18 patients with mania, 23 patients with depression and 27 healthy individuals.

2.3. Mathematical analyses

We calculated means for the whole recording period and for the 64-min periods of continuous motor activity. As measures of variability in activity counts, for each time series we also calculated:

a) the standard deviation (SD) as an intra-individual measure of fluctuations from the mean
b) the root mean squared successive difference (RMSSD), which describes the difference in successive counts from minute to minute
c) the RMSSD/SD ratio

For the 64-min periods we further assessed:

a) sample entropy as a measure of complexity or irregularity
b) autocorrelation (lag 1)
c) ratios between high-frequency and low-frequency variance in a Fourier analysis

All these mathematical approaches characterize different phenomena of a time series: mean levels, variability and complexity features. For the calculation of sample entropy and the Fourier analysis, free software is available from the Physio Toolkit Research Resource for Complex Physiologic signals (Goldberger et al., 2000), see http://www.physionet.org.

2.3.1. Sample entropy

Sample entropy is a nonlinear measure that indicates the degree of regularity (complexity) of a time series. A low sample entropy value corresponds to a more regular series. It is the negative natural logarithm of an estimate of the conditional probability that subseries of a certain length (m) that match point-wise, within a tolerance (r), also match at the next point. We chose the following values, $m = 2$ and