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Gait and motor imagery of gait in early schizophrenia

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ABSTRACT

Although gait disorders were described in schizophrenia, motor imagery of gait has not yet been studied in this pathology. We compared gait, motor imagery of gait and the difference between these two conditions in patients with schizophrenia and healthy age-matched controls. The mean ± standard deviation (S.D.) of Timed Up and Go (TUG), imagined TUG (iTUG) and delta time (i.e.; difference between TUG and iTUG), was used as outcomes. Covariables include Mini Mental State Examination, the Frontal Assessment Battery (FAB), FAB's subitems, the Positive and Negative Syndrome Scale and the Unified Parkinson's Disease Rating Scale (UPDRS). Seventeen patients with early schizophrenia and 15 healthy age-matched controls were assessed. Schizophrenia patients performed the TUG and the iTUG slower than the controls. Multivariate linear regressions showed that iTUG and delta time were associated with the conflicting instruction of the FAB. The present study provides the first evidence that patients with schizophrenia performed gait and motor imagery of gait slower than healthy controls. These deficits could be in part explained by impaired executive function and specifically by a disturbance in the sensitivity to interference.

1. Introduction

Before the advent of neuroleptics, gait disorders were described in patients with schizophrenia as a characteristic of the illness (Bleuler, 1911). Quantitative gait analysis confirmed these descriptions and showed a decrease of gait velocity due to a shorter stride length (Putzhammer et al., 2005). Ataxic gait in patients with schizophrenia seems also to be more frequent than in control subjects, and is related to old age and previous history of alcohol abuse, involving a dysfunction of the visuo-cerebellar circuit (Jeon et al., 2007). In addition, it was shown in patients with schizophrenia that infant motor developmental delay was associated with deficits in cognitive function involving executive function in adults (Murray et al., 2006). This last description suggests that executive function could contribute to motor disorders in schizophrenia (Brebion et al., 2000).

Motor imagery (MI) refers to the mental simulation of an action without its actual execution (Jeannerod, 1995). Previous reports on Parkinson's disease in particular suggested that MI shares common neural structures with motor execution (Jeannerod, 1994; Dominey et al., 1995) and the frontostriatal structures is one of these regions (Dominey et al., 1995). Furthermore, in the realization of motor representations into motor performances, the dopaminergic system seems to play an important role (Yaguez et al., 1999). A recent study on MI of locomotion showed that practice of MI modulates brain networks including supplementary motor area, basal ganglia, bilateral thalamus and right cerebellum (Ionta et al., 2010). Concerning schizophrenia, a review on MI in this pathology suggested an important role of the posterior parietal cortex in attentional dysfunctions and impairments in MI (Danckert et al., 2004).

To assess gait and MI of gait, we recently adapted an imagined version of the Timed Up and Go (TUG) (Beauchet et al., 2010). TUG is a basic test for the evaluation of functional mobility, measuring time while standing up, walking, turning and sitting down and it has been used to evaluate gait and balance performance (Podsiadlo and Richardson, 1991). We showed a relationship between the discrepancy of the time to perform the TUG and the imagined time to perform the TUG (delta time) and Mini Mental State Examination (MMSE) (Folstein et al., 1975) in a sample of older adults (Beauchet et al., 2010). Due to the absence of study on MI of locomotion in schizophrenia, we used this adapted version of the TUG in this population. Because of the role of the dopaminergic system and the suspected relationship between, on the one hand, gait disorders and cognitive function and, on the other, deficits in MI and cognitive function in schizophrenia, we hypothesized that slower TUG and imagined TUG (iTUG) would be observed in patients with schizophrenia. The objective of this prospective cross-sectional study was 1) to measure and compare the time of TUG, iTUG and the difference of time between these two conditions of realization (i.e., delta time) in a sample of patients with schizophrenia and healthy matched controls and 2) to

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examine whether there was an association between the performances of TUG, iTUG and delta time and the cognitive status.

2. Method

2.1. Participants

A total of 32 participants were enrolled in the study: 17 patients with schizophrenia (mean age 30±9 years, 50% women) and 15 healthy age and gender-matched controls (Table 1a). Patients with schizophrenia were recruited in the 10th unit of the Ville Evrard Hospital and control subjects in the campus of the Pitié-Salpêtrière Hospital.

The patients group met DSM-IV criteria for schizophrenia according to the Structured Clinical Interview for DSM-IV Axis I disorders (SCID) (eight paranoid, one disorganized and eight undifferentiated types). Positive and negative symptoms were also evaluated with the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987) by a psychiatrist of the unit of the Ville Evrard Hospital on the day of the experiment. Neuropsychological assessment, included Folstein's MMSE (Folstein et al., 1975), Stroop Test (Stroop, 1935), Trail Making Test (TMT) (U.S. War Department, 1944; Reitan, 1955) and the Frontal Assessment Battery (FAB) (Dubois et al., 2000). The FAB is a short bedside cognitive and behavioral battery assessing frontal lobe function. It consists of six subtests exploring conceptualization, mental flexibility, motor programming, sensitivity to interference, inhibitory control and environmental autonomy. The global scores of the FAB (/18) and its six subscores (/3) are presented in Table 1a. Extrapyramidal rigidity was evaluated with Unified Parkinson's Disease Rating Scale (UPDRS): the total UPDRS score refers to part III of the UPDRS (motor examination, item 18–31 assessing speech, facial expression, tremor, tonus, finger tapping, hand movements, leg agility, posture, gait and body bradykinesia); and the gait score refers to the item 29 of the UPDRS assessing specifically gait function. All tests were performed on the day of the experiment for both schizophrenic patients and healthy controls. All schizophrenic patients were on neuroleptic drugs (three typical, 14 atypical) without any modification in the previous 3 months. They were stable and were taking the same treatment for at least 4 weeks and for not more than 12 weeks. Schizophrenic patients treated with antidepressants, benzodiazepines, anticholinergics, or lithium for a time period superior to 1 month were excluded from the study. Exclusion criteria included other physical illness involving the central nervous system, current substance and/or alcohol abuse, and clinical evidence of mental retardation or any pathology interfering with gait. The mean illness-duration was 5 years (S.D. 3). Exclusion criteria for healthy controls were neurological and psychiatric disorders, substance abuse, or any pathology interfering with gait. Clinical and demographic characteristics of the participants are displayed in Tables 1a and 1b. After a complete description of the study to the participants, written informed consent was obtained. The study was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki (1983). The local ethics committee approved the project.

Table 1a
Clinical characteristics of participants ($n=32$).

	Normal ($n=15$)	Schizophrenia ($n=17$)	P-value[a]
Age, mean±S.D. (years)	29±5	30±9	0.309
Female, *n* (%)	7 (46.7)	9 (52.9)	1
Education (/3)	3±0	2.5±1	0.017
Neuropsychology			
Mini-mental state	30±0	28±2	<0.001
FAB (total score)	18±0	14±4	<0.001
Similarities (conceptualization)	3±0	3±1	0.007
Lexical fluency (mental flexibility)	3±0	2±1	<0.001
Prehension behavior (environmental autonomy)	3±0	3±0	1
Motor series (programming)	3±0	2±1	0.001
Conflicting instructions (sensitivity to interference)	3±0	3±2	0.029
Go–No Go (inhibitory control)	3±0	3±1	0.001
TMT-A	22±6.8	51±53	<0.001
TMT-B	42±14	166±178	<0.001
Stroop (word)	136±38	102±22	<0.001
Stroop (color)	98±27	71±14	<0.001
Stroop (interference)	71±16	33±12	<0.001
Similitude test	26±4	14±10	<0.001
Letter-number sequence	11±7	7±5	0.007
UPDRS			
Total score	0±0	5.0±1.6	<0.001
Gait score (1/4) *n* (%)	0 (0)	9 (53)	<0.001

UPDRS: Unified Parkinson's Disease Rating Scale (Total score refers to part III of the UPDRS; Gait score refers to the item 29 of the UPDRS).
[a] Comparison based on Mann–Whitney test or Fisher-exact test, as appropriate.

Table 1b
Clinical characteristics of schizophrenia patients ($n=17$).

	Schizophrenia ($n=17$)
Years of illness±S.D. (years)	5±3
Type of schizophrenia	
Paranoid	8
Disorganized	1
Undifferentiated	8
Treatment	
Typical neuroleptic	1
Atypical neuroleptic	14
Phenothiazine	2
Antidepressant	4
Benzodiazepine	1
PANSS score	
Positive (/49)	21±7
Negative (/49)	21±15
General psycho	47±11

2.2. Procedures

This study used the TUG test described by Podsiadlo and Richardson (1991). The participants were asked to perform the TUG at their self-selected speed in a well-lit environment. They all completed one trial for both the TUG and the iTUG in the following order: performing then imaging the TUG test while sitting on a chair. The time of each walking and imagined conditions was recorded with a stopwatch to the nearest 0.01 s. Before testing, the same trained evaluator (EL) gave standardized verbal instructions regarding the test procedure: For the TUG, the participants were seated, allowed to use the armchairs to help them to stand up. They were asked to walk 3 m, turn around, walk back to the chair and sit down. The stopwatch was started on the word "go" and stopped as the participant sat down. For the imagined condition (iTUG), the test was performed like in the study of test validation (Beauchet et al., 2010): the participants were sitting on the armchair and asked to imagine performing the TUG-test, meaning to imagine to stand up, to walk 3 m turn around, walk back to the chair and sit down. They chose to perform iTUG eyes opened or closed. The stopwatch was started on the order "go" and stopped when the participant pronounced the word "stop". The participants were free to use motor or visual imagery while performing iTUG. We did not control for the choice of the mental imagery strategy.

2.3. Outcomes

The outcomes were as follows: 1) the mean±S.D. time to execute and to imagine the TUG test (respectively, TUG and iTUG), 2) the mean±S.D. difference of time (i.e. delta time) between both TUG conditions calculated following the formula: $(TUG-iTUG)/[(TUG+iTUG)/2]\times 100$; and 3) the cognitive function with scores of MMSE, FAB, TMT-A and B, Stroop Test.

2.4. Statistical analysis

The participants' characteristics were summarized using means and standard deviations or frequencies and percentages, as appropriate. The normality of the parameters' distribution was verified with skewness and kurtosis tests before and after applying usual transformations to normalize non-Gaussian variables (TUG was normalized using an inverse transform, iTUG with an inverse square transform and no transformation for delta time) (Kleinbaum et al., 1987). Comparisons between groups of participants were performed using the independent samples *t*-test and χ^2 test as appropriate. Simple and bivariate linear regression analyses were performed to specify the association between TUG, iTUG, delta time and covariates. A stepwise forward procedure was also applied to reduce the number of variables in the regression models. A repeated measure analysis of variance (ANOVA) model was used to explain performance time and check for the effects of group (patients versus controls), the effect of task (performed and imagined TUG) along with their interaction, with task being the repeated factor. *P*-values less than 0.05 were considered as statistically significant. All the statistics were performed using the Stata Statistical Software, version 10.1.

3. Results

3.1. Clinical characteristics

The global cognitive score assessed by MMSE was statistically different between both groups (30±0 for the control group; 28±2 for patients with schizophrenia; $P<0.001$). All the tests assessing the performance of executive functioning was worse in the schizophrenic group compared to the control group ($P<0.050$) with the exception