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Construction and validation of the Dynamic Parkinson Gait Scale (DYPAGS)

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ABSTRACT

The dynamic evaluation of Parkinson's disease (PD)-related episodic gait disturbances in routine is challenging. Therefore, the aim of our study was to assess the reliability/validity of the Dynamic Parkinson Gait Scale (DYPAGS) composed of eight relevant items for the objective quantification of PD gait features: walking forwards/backwards/with dual-task, turning to both sides, imaginary obstacle avoidance with both legs and passing through narrow spaces. The scale was validated on thirty-five patients with mild to severe parkinsonism in their habitual "on-state". A shorter 6 item-version was designed on the basis of a principal component analysis. No significant floor/ceiling effect was detected. The internal consistency was excellent. The levels of interrater agreement, precision and minimal detectable change were adequate. The criterion-related validity was demonstrated by strong correlations with the DYPAGS scores and those at the gait subscales of the Tinetti Mobility Test and MDS-UPDRS. The construct validity was assessed by moderate-strong correlations with the Freezing of Gait Questionnaire, mobility index of the PD Questionnaire (PDQ-39), disease duration and levodopa equivalent daily doses. Statistical analyses using the coefficient of determination showed that both DYPGAS versions were superior to the other instruments to identify patients with gait disturbances with poorer response to dopaminergic treatment. Full and short DYPAGS are reliable instruments for the quantification of "on" PD-related episodic gait disturbances. The full version is sensitive to detect subtle disturbances in mild parkinsonism. The shorter one is easily administered and reliably quantifies gait disturbances in moderate to severe parkinsonism. We recommend their use for research and clinical practice.

1. Introduction

Episodic gait disturbances are highly disabling in Parkinson's disease (PD). They encompass a wide continuous spectrum of manifestations ranging from subtle hesitation to minutes of gait akinesia [1]. They preferentially occur during certain phases of gait which are ignition, making a turn or approaching the target, and in situations that differ from the "baseline gait" such as passing through narrow passages, walking while performing a dual-task [1–3], and walking backwards [4]. Quantifying these disturbances is of importance as the therapeutic approach may depend on their severity. Habitual PD-related gait disturbances may be assessed using non-dynamic instruments such as the Freezing of Gait Questionnaire (FOG-Q) [2]. Additionally to the clinician's judgment which remains the gold standard, several instruments may be helpful in the dynamic evaluation of gait disturbances in PD [5–11]. These instruments have however major limitations: they lack sensitivity, they categorize patients as with/without severe gait disturbances (i.e., gait freezing) which should be considered as a continuum with numerous intermediate stages [1], they do not reflect habitual gait, or their performances are altered by fatigue rather than specific PD-related gait disturbances.

Here, we assess the reliability and validity of the full and short versions of the Dynamic Parkinson Gait Scale (DYPAGS) aiming at quantifying the severity of habitual PD-related episodic gait disturbances.

2. Methods

2.1. Patients

Thirty-two patients diagnosed with PD [12] and three with probable "Parkinson-plus syndromes" were recruited in their "habitual on-state" (Table 1). Written consents for this research protocol approved by the local Ethic Committee were obtained from all patients.

Habitual gait disturbances were evaluated using the FOG-Q and the mobility index of the PD Questionnaire (PDQ-39_{gait}) [13]. Motor scores at the Movement

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Table 1
Demographic and clinical patients' data and their relationship with the full and short versions of the Dynamic Parkinson Gait Scale (DYPAGS).

	Mean ± SD	Median	Correlation with DYPAGS (r_s)	Correlation with short DYPAGS (r_s)
Age (years)	66.2 ± 8.9	66	−0.10 ($P = 0.551$)	−0.16 ($P = 0.362$)
Gender (male %)	74.3 ± 44.3	100	0.13 ($P = 0.469$)	0.08 ($P = 0.629$)
Disease duration (years)	8.1 ± 4.7	8	0.44 ($P = 0.011$)*	0.45 ($P = 0.011$)
Levodopa equivalent daily doses (mg)	824 ± 413	812	0.48 ($P = 0.004$)**	0.40 ($P = 0.019$)*
FOG-Q	9.8 ± 6.1	8	0.74 ($P < 0.001$)**	0.74 ($P < 0.001$)**
PDQ-$39_{mobility}$	35.3 ± 23.7	35	0.58 ($P < 0.001$)**	0.56 ($P < 0.001$)**
MDS-$UPDRS_{gait}$	2.1 ± 2	1	0.81 ($P < 0.001$)**	0.82 ($P < 0.001$)**
TMT_{gait} score	8.8 ± 3.2	10	−0.71 ($P < 0.001$)**	−0.73 ($P < 0.001$)**
DYPAGS	13.3 ± 8.7	11	n/a	0.99 ($P < 0.001$)**
Short DYPAGS	9.3 ± 6.6	8	0.99 ($P < 0.001$)**	n/a

SD = standard deviation. r_s = Spearman rank correlation coefficient. FOG-Q = Freezing of Gait Questionnaire. PDQ-$39_{mobility}$ = mobility index of the Parkinson's disease Questionnaire (PDQ-39). MDS-$UPDRS_{gait}$ = summed scores of items 3.10 (gait) and 3.11 (gait freezing) of the Movement Disorders Society sponsored review of the Unified Parkinson's Disease Rating Scale. TMT_{gait} = gait subscale of the Tinetti Mobility Test. DYPAGS = 8 item-Dynamic Parkinson Gait Scale. short DYPAGS = 6 item-DYPAGS. n/a = not applicable.
* = significant without Bonferroni correction. ** = significant after Bonferroni correction.

Disorders Society sponsored review of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS) [14], and scores at the gait subscale of the Tinetti Mobility Test (TMT_{gait}) [8] were obtained prior to the administration of the DYPAGS.

2.2. Construction of the DYPAGS

We made a review of articles that mentioned dynamic instruments used to assess gait disturbances in parkinsonism. These were the items 3.10 (gait) and 3.11 (gait freezing) of the MDS-UPDRS [14], TMT_{gait} [8], 6 min-walking distance [6], 10 m-walk test [9], Stand–Walk–Sit test [5], Timed up and Go test [7,10], Dynamic Gait Index [7] and FOG-score [11]. All items of these instruments were analyzed in order to select those felt the most relevant to elicit PD-related gait disturbances and to reflect the spectrum of gait in the patients' habitual environment.

Eight dynamic items were adapted from these instruments: walking 7 m forwards, walking 3 m backwards, turning 360° on the same place to the right/left, stepping over an imaginary obstacle with the right/left leg, passing through a 50 cm-space made between two chairs, and walking while performing a cognitive dual-task that consisted in quoting animal names (see Appendix).

To design the scoring algorithm, we selected PD-related gait features that could be visually unmasked: start/destination/turning hesitation, step count, increased double-support time, foot clearance, fall/near fall, motor block (defined as the foot stuck onto the ground with or without trembling in place during >1 s), and accelerated short shuffling steps [1,3]. Each item obeyed a 6 point-ordinal scoring system (range: 0–5). A high score (maximum possible total score: 40) reflected severe PD-related gait disturbances. The scoring system followed a stepwise judgment. In all items, the inability to move the leading foot (complete akinesia) and/or fall was considered as item maximum possible score. In items whose achievement required a predefined distance (walking forwards with/without dual-task and walking backwards) or revolution (turning to the right/left), the inability to perform the task in its integrality and/or near fall was scored 4. In achieved items involving straight locomotion (walking forwards with/without dual-task and walking backwards), narrowing the range of scores from 3 to 0, score was assessed on the basis of our intuitive appreciation of PD-related gait disturbances according to the following paradigm: motor block/accelerated short steps > hesitation/impaired feet clearance > slow gait/increased double-support/subtle hesitation > normal gait. In the case of walking with dual-task, the quality of the cognitive task was verified by counting the number of correct quotations. In achieved turning, the score decreased as a function of the step count. In achieved imaginary obstacle avoidance, the score was an inverse function of the step width relatively to the patient's height. Finally, when patients could pass through tight quarters, their scores were related to hesitation and/or motor block/accelerated short steps between the chairs.

2.3. DYPAGS administration

The patients were asked to perform all the tasks fluently as soon as they heard the start-signal. During the cognitive dual-task, they were asked to quote as many animal names as possible. They were asked to perform turning with minimal number of steps. During the imaginary obstacle avoidance, they were requested to make the widest step (assessed online with a tape-measure) as possible.

The DYPAGS administration was video-taped and the visual analysis of all the data, exception to the "imaginary obstacle avoidance" items, was performed offline using a media player equipped with a timer allowing the assessment of <1 s *versus* >1 s hesitations. Items were scored by four neurologists blinded towards the others using the proposed algorithm (see Appendix).

2.4. Statistical analyses

The scores measured by rater 1 were used to perform statistics against clinical data, principal component analysis and to verify the floor and ceiling effects, internal consistency and standard error of measurement. The paired "turning" and "imaginary obstacle avoidance" scores were corrected in function of the more affected side instead of right/left laterality.

Data analyses were conducted using the *R Project for Statistical Computing version 2.13.1* (http://www.r-project.org).

2.4.1. Scale construction

A correlation matrix expressing the relationships among all the items scored in the fifty-five subjects was computed in order to verify item redundancy. Two items were considered as potentially redundant if their Spearman correlation coefficient exceeded 0.80. As the paired "turning" and "imaginary obstacle avoidance" items met this criterion (see results), only one of each condition was selected on the basis of its capacity to predict habitual PD-related gait disturbances. This was assessed using the coefficient of determination R^2 between the item score and scores at

Table 2
Comparison of the paired turning and imaginary obstacle avoidance items in function of the disease laterality.

	Turning		Imaginary obstacle avoidance	
	Less affected side	More affected side	Less affected side	More affected side
Mean ± SD	1.71 ± 1.29	2.12 ± 1.30	1.52 ± 1.42	1.74 ± 1.35
Median	1	2	1	2
Correlation with FOG-Q (R^2)	0.52	0.50	0.51	0.38
Correlation with MDS-$UPDRS_{gait}$ (R^2)	0.63	0.52	0.68	0.59

SD = standard deviation. FOG-Q = Freezing of Gait Questionnaire. MDS-$UPDRS_{gait}$ = summed scores of items 3.10 (gait) and 3.11 (gait freezing) of the Movement Disorders Society sponsored review of the Unified Parkinson's Disease Rating Scale. R^2 = coefficient of determination. Paired Wilcoxon rank tests showed that the turning scores related to the more affected side were higher than those related to the less affected side ($P < 0.001$), so were the imaginary obstacle avoidance scores performed with the more affected compared with the less affected leg ($P = 0.006$).