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Published in:
Archives of Physical Medicine and Rehabilitation

DOI:
[10.1016/j.apmr.2017.03.016](https://doi.org/10.1016/j.apmr.2017.03.016)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2017

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Vlagsma, T. T., Koerts, J., Tucha, O., Dijkstra, H. T., Duits, A. A., van Laar, T., & Spikman, J. M. (2017). Objective Versus Subjective Measures of Executive Functions: Predictors of Participation and Quality of Life in Parkinson Disease? *Archives of Physical Medicine and Rehabilitation*, 98(11), 2181-2187. <https://doi.org/10.1016/j.apmr.2017.03.016>

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ORIGINAL RESEARCH

Objective Versus Subjective Measures of Executive Functions: Predictors of Participation and Quality of Life in Parkinson Disease?

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Abstract

Objectives: To determine whether objective (neuropsychological tests) and subjective measures (questionnaires) of executive functions (EFs) are associated in patients with Parkinson disease (PD), and to determine to what extent level of participation and quality of life (QoL) of patients with PD can be predicted by these measures of EFs.

Design: Correlational research design (case-control and prediction design).

Setting: Departments of neuropsychology of 3 medical centers.

Participants: A sample (N=136) of patients with PD (n=42) and their relatives, and controls without PD (n=94).

Interventions: Not applicable.

Main Outcome Measures: A test battery measuring EFs. In addition, patients, their relatives, and controls completed the Dysexecutive Questionnaire, Brock Adaptive Functioning Questionnaire, and Barkley Deficits in Executive Functioning Scale — time management questionnaires measuring complaints about EFs. Participation and QoL were measured with the Impact on Participation and Autonomy scale and the Parkinson's Disease Questionnaire-39, respectively.

Results: Patients with PD showed impairments in EFs on objective tests and reported significantly more complaints about EFs than did controls without PD. No associations were found between patients' performances on objective and subjective measures of EFs. However, both objective and subjective measures predicted patients' level of participation. In addition, subjective measures of EFs predicted QoL in patients with PD.

Conclusions: These findings show that objective and subjective measures of EFs are not interchangeable and that both approaches predict level of participation and QoL in patients with PD. However, within this context, sex needs to be taken into account.

Archives of Physical Medicine and Rehabilitation 2017;98:2181-7

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Cognitive impairments, including impairments in executive functions (EFs), are frequently found in patients with Parkinson disease (PD).^{1,2} Impairments in EFs can already be present in patients with newly diagnosed PD and have a negative influence

on patients' level of participation^{3,4} and quality of life (QoL).^{5,6} EF is an umbrella term that encompasses several higher-order capacities important for adequate and independent daily living, because they enable us to adapt to new nonroutine situations and to act in a goal-oriented way.⁷

Neuropsychological tests are used to measure impairments in EFs objectively. However, these tests are usually administered in a standardized setting offering a large amount of structure; that is, detailed instructions are given and external distractions are minimized. Consequently, performances on objective basic

Supported by the Netherlands Organisation for Scientific Research (NWO), the National Initiative Brain & Cognition (grant no. 056-11-012). This quick-result project is embedded in the pillar "The Healthy Brain, Program Cognitive Rehabilitation."

Clinical Trial Registration No.: ISRCTN13595005.

Disclosures: none.

neuropsychological tests (eg, Trail Making Test⁸) might not reflect complex unstructured daily life situations that require higher-order aspects of executive functioning,⁹ such as goal setting and planning. Therefore, the ecological validity of many standard tests of EFs is considered to be low.^{10,11} The Behavioural Assessment of the Dysexecutive Syndrome (BADS)¹² is a neuropsychological test battery consisting of 6 subtests that is within the field of neuropsychology considered to be the most valid ecological measure for EFs. The predictive value for the BADS for daily life functioning is higher than that for the regular EF tests, but still limited.^{13,14} An example of a task that better resembles daily life executive functioning is the Executive Secretarial Task, which is a performance-based task as it was designed to be a simulation of a job assessment procedure.¹⁵ Also in the field of occupational therapy, performance-based assessments resembling daily life tasks (ie, performance of daily life activities, such as cooking) are performed to measure EFs in an ecologically valid way.¹⁶ A large drawback of this kind of measures is that their assessment is time-consuming than is the case for regular neuropsychological tests; for instance, the administration of the Executive Secretarial Task takes 3 hours. This makes this kind of performance-based measures less suitable for use in regular neuropsychological assessment.

In contrast to neuropsychological tests that allow objective measurement, questionnaires can be used to measure the subjective experience of EF problems as well as patients' and their relatives' burden related to these EF problems in daily life.¹⁷ However, if patients have impaired self-awareness, which is common in neurological disorders, self-report questionnaires might not give an accurate representation of patients' functioning. This problem can be partly overcome by using proxy versions, which may also give an indication of patients' self-awareness by comparing judgments of patients and their relatives. Furthermore, various other factors might influence self-reports of patients. For example, in patients with PD the presence of depression or anxiety has been found to have a negative influence on the number and severity of complaints.^{18,19} The objective and subjective approaches thus measure problems in EFs from a different perspective, and therefore it is important to study their mutual relation.

Previous studies showed that correlations between impairments in EFs, measured with objective measures, and complaints about EFs, reported on subjective measures, are weak in populations of patients with neurological disorders.^{20,21} For instance, patients with PD who report complaints about EFs do not necessarily show impairments on tests of EFs, and vice versa.^{18,22-24} One explanation for this weak association is that neuropsychological tests and questionnaires measure EFs at different levels, because objective tests assess EFs in a standardized environment and

require patients to show an optimal performance, whereas questionnaires do not focus on performance, but ask for normal functioning in daily life.²⁵

According to the World Health Organization's International Classification of Functioning, Disability and Health,²⁶ a disease can influence a patient's life on several hierarchical and interrelated levels: functional level (ie, cognitive or physical impairments), daily life activity level, and participation level (ie, involvement in societal domains such as work and mobility). In this context, *QoL*, defined as the subjective evaluation of various aspects (eg, health or social functioning) of life in the context of one's needs and expectations, is an important concept.⁵ Currently not much is known about the extent to which International Classification of Functioning, Disability and Health levels and *QoL* are interrelated in PD; for example, to what extent do impairments in EFs (ie, functional level) have an influence on level of participation and *QoL* of patients? Therefore, this study aims to determine whether level of participation and *QoL* of patients with PD can be predicted by impairments at a functional level, as measured with both objective and subjective measures. It is expected that especially the combination of both objective and subjective measures, instead of using these approaches separately, will be of added value in predicting patients' level of participation and *QoL*.

Methods

Participants

Forty-two patients with idiopathic PD were included who were diagnosed according to the UK Parkinson's Disease Brain Bank Criteria. Patients were recruited at the departments of neurology of 3 medical centers in the Netherlands. Patients were selected by a neurologist during regular consultation hours and were considered eligible for participation in this study when they reported problems in EFs in daily life and had a mild disease severity (Hoehn and Yahr scale, stage 1–3). Severe neurological and psychiatric comorbidities, including dementia (ie, *SCoLES* for Outcomes in *PA*rkinson's disease – *COGN*ition score ≤ 17)²⁷ formed exclusion criteria. Disease severity was determined with the Unified Parkinson's Disease Rating Scale motor part (part III) and Hoehn and Yahr scale. Patients in Hoehn and Yahr stage 4 and 5 were not included in this study. A levodopa equivalent daily dose²⁸ was calculated for all patients receiving dopaminergic treatment. Five patients were not receiving dopaminergic treatment, 2 patients did not report medication use, and 2 received deep brain stimulation, which was performed at least 1 year before study inclusion. Patients receiving dopaminergic treatment were assessed in the on phase. Furthermore, at the time of inclusion, 11 patients were employed (of which 5 patients had made adjustments to their work activities or hours) and 31 patients were unemployed, either because they reached the age of retirement ($n=24$) or they had decided to quit their jobs before retirement age because of their disease ($n=7$). With regard to the data that were collected from proxies, 2 patients were unable to find a life partner or relative willing to participate, 1 daughter of a patient participated, and the other 39 patients found their life partner willing to fill out questionnaires.

In addition, 94 controls without PD were included. No significant differences were found between groups with regard to age and level of education, but the groups did significantly differ in sex (table 1). This study obtained approval of a medical ethical

List of abbreviations:

BADS	Behavioural Assessment of the Dysexecutive Syndrome
BAFQ	Brock Adaptive Functioning Questionnaire
BDEFS	Barkley Deficits in Executive Functioning Scale
DEX	Dysexecutive Questionnaire
EF	executive functions
HADS	Hospital Anxiety and Depression Scale
IPA	Impact on Participation and Autonomy
PD	Parkinson disease
PDQ-39	Parkinson's Disease Questionnaire-39
QoL	quality of life

Table 1 Descriptive and disease characteristics of patients with PD and controls without PD

Characteristic	Patients With PD (n=42)		Controls Without PD (n=94)			P
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	t/U/ χ^2	
Age (y)	60.8 $\pm$ 9.9	42–77	58.5 $\pm$ 6.8	38–84	1.31	.197
Education*	5.6 $\pm$ 1.1	3–7	5.3 $\pm$ 0.9	3–7	1663.50	.082
Sex†					3.98	.046
Male, n (%)	27 (64.3)	NA	43 (45.7)	NA	NA	NA
Female, n (%)	15 (35.7)	NA	51 (54.3)	NA	NA	NA
UPDRS part III score (range, 0–108)	20.3 $\pm$ 9.5	8–59	NA	NA	NA	NA
H&Y stage score (range, 1–5)	2.1 $\pm$ 0.6	1–3	NA	NA	NA	NA
LEDD	718.3 $\pm$ 622.3	0–3020	NA	NA	NA	NA
SCOPA-COG score	29.1 $\pm$ 4.5	19–37	NA	NA	NA	NA
HADS score						
Anxiety	6.7 $\pm$ 3.3	2–15	4.0 $\pm$ 2.7	0–12	NA	NA
Depression	6.1 $\pm$ 3.0	0–13	2.6 $\pm$ 2.6	0–11	NA	NA

NOTE. Educational level was classified using a 7-point scale: 1 = <6y primary school and 7 = university degree.

Abbreviations: H&Y, Hoehn and Yahr scale; LEDD, levodopa equivalent daily dose; NA, not applicable; SCOPA-COG, Scales for Outcomes in Parkinson's Disease – COGnition; UPDRS part III, Unified Parkinson's Disease Rating Scale motor part.

* Mann-Whitney U test.

† χ^2 test.

committee in the Netherlands and was conducted in agreement with the Declaration of Helsinki. All participants signed an informed consent.

Neuropsychological assessment

Procedure

Before the neuropsychological assessment was administered, patients received the questionnaires at home. They were asked to fill them out and bring the questionnaires with them to their appointment. To minimize the chance that on-off fluctuations would occur during the neuropsychological assessment, patients were asked beforehand about their medication use and at what time they needed to take their medication. The test assistant reminded patients, if necessary, at these time points to take their medication to prevent them from going to an off phase, which affects cognitive performance. The time from taking dopaminergic medication to the start of the tests varied slightly; however, given that all patients were assessed at the same time in the morning at the neuropsychology departments of the respective hospitals and that patients usually take their first medication when they get up from bed, the time between intake of medication and start of the tests was minimized.

Objective measures of EFs

EFs were assessed with the Trail Making Test B/A ratio, Stroop Color-Word/Color card ratio, Visual Elevator Test (a subtest of the Test of Everyday Attention) total score, Verbal Fluency Test (total score of 3 letters), and Zoo Map (subtest of the BADS) total score.

Subjective measures of EFs

The Dysexecutive Questionnaire (DEX; total score) was used to assess problems in executive functioning in daily life. The “time management” scale of the Barkley Deficits in Executive Functioning Scale (BDEFS; total score) was used to measure patients' time management capacities. The scale also includes questions about taking initiative and distractibility, because these aspects

can influence the time management capacities. The Brock Adaptive Functioning Questionnaire (BAFQ; mean total score of 12 scales) was used to measure cognitive and behavioral aspects of adaptive functioning. All questionnaires consisted of self-rating and proxy-rating versions (eg, completed by the partner). Controls completed only self-rating versions of the questionnaires. On all questionnaires, higher scores represent more complaints.

Level of participation and QoL

The Impact on Participation and Autonomy (IPA) scale (total score on the subscales “activities in or around the house” and “social relations”) was used to assess patients' level of participation. Health-related QoL was measured with the Parkinson's Disease Questionnaire-39 (PDQ-39; total score). On both questionnaires, higher scores represent lower levels of participation or QoL.

Anxiety and depression

Symptoms of anxiety and depression were measured with the Hospital Anxiety and Depression Scale (HADS; total score and separate scores of anxiety and depression subscales).

Statistical analyses

Analyses of covariance were conducted to compare the groups on neuropsychological test measures and questionnaires of EFs. Because patients showed significantly higher scores on both subscales of the HADS and more men were included in the patient group (anxiety subscale: $t=4.67$, $P<.001$; depression subscale: $t=6.87$, $P<.001$) (see table 1), HADS scores and sex were included as covariates. Test performances of all participants were also analyzed from a clinical perspective; that is, test scores were compared with normative data and considered as being “impaired” when a score fell within the lowest 10% of the normative sample.²⁹ Paired-samples t tests were used to compare evaluations of patients and their relatives on questionnaires of EFs. Furthermore, effect sizes (Cohen d) were calculated. Associations between

Table 2 Performance of patients with PD and HC on objective and subjective measures of EFs

Measure	Patients With PD (n = 42)		Controls without PD (n = 94)		%≤10th pc (n)	χ ²	ANCOVA			Sign. Covariates			
	Mean ± SD	%≤10th pc (n)	Mean ± SD	%≤10th pc (n)			P	F	P	Sex	HADS-A	HADS-D	ES
Objective													
TMT B/A	2.60±1.01	23.81 (10)	2.16±0.55	5.56 (5)	7.61	.006*	5.52	.020	NS	NS	NS	0.60	
Stroop 3/2	1.63±0.28	4.76 (2)	1.55±0.19	0.00 (0)			2.18	.144	NS	NS	NS	0.35	
Visual Elevator Test	7.56±2.22	20.51 (8)	8.51±1.63	7.95 (7)	4.09	.043*	7.70	.006 ⁺	NS	NS	*	0.52	
Verbal Fluency Test	38.69±11.76	16.67 (7)	39.88±11.74	12.77 (12)			0.59	.443	NS	NS	NS	0.10	
BADS Zoo Map	8.64±5.01	38.10 (16)	10.26±5.21	18.09 (17)	6.33	.012*	3.83	.053	NS	NS	NS	0.31	
Subjective													
DEX	25.83±11.09	NA	14.91±8.03	NA	NA	NA	9.57	.002 ⁺	NS	*	NS	1.20	
BAFQ	2.25±0.42	NA	1.79±0.37	NA	NA	NA	7.34	.008 ⁺	*	*	NS	1.18	
BDEFS-tm	45.18±12.07	NA	29.77±6.27	NA	NA	NA	22.52	<.001 ⁺	NS	*	NS	1.54	

NOTE. *Significant *P* value was less than Bonferroni-corrected α . *Comparison between groups on % impairments and covariates: and $P < .05$.

Abbreviations: ANCOVA, analysis of covariance; BADS Zoo Map, Behavioural Assessment of the Dysexecutive Syndrome Zoo Map subtest; BDEFS-tm, Barkley Deficits in Executive Functioning Scale – time management; ES, effect size; HADS-A, Hospital Anxiety and Depression Scale anxiety subscale; HADS-D, Hospital Anxiety and Depression Scale depression subscale; NA, not applicable; NS, not significant; pc, percentile; Sign., significant; Stroop 3/2, Stroop Color-Word/Color card ratio; TMT B/A, Trail Making Test B/A ratio.

objective and subjective measures of EFs and measures of participation and QoL were analyzed using Pearson correlations within the patient group. Finally, 2 multiple regression analyses (method: enter) were used to determine whether objective and subjective measures can predict level of participation (dependent variable: IPA scale) and QoL (dependent variable: PDQ-39) in patients. To reduce the number of independent variables, the objective and subjective measures of EFs showing the highest mean correlation with the dependent variables (ie, IPA scale and PDQ-39) were included in the model. Moreover, the descriptive variables age, sex, Unified Parkinson's Disease Rating Scale total score, and HADS total score (sum score of anxiety and depression subscales) were included as predictors. Statistical significance was reached at $\alpha < .05$. In case of multiple comparisons, a Bonferroni correction was applied.

Results

Performance on objective measures

Patients with PD performed significantly worse than controls on the Visual Elevator Test when corrected for sex and HADS scores (table 2). No significant differences were found between groups on the other test measures of EFs, which is consistent with the marginal to medium effect sizes. However, from a clinical perspective, patients showed a significantly higher percentage of impaired performances than did controls on 3 of 5 neuropsychological tests (Trail Making Test B/A ratio: $\chi^2 = 7.61$, $P = .006$; Visual Elevator Test: $\chi^2 = 4.09$, $P = .043$; BADS Zoo Map subtest: $\chi^2 = 6.33$, $P = .012$).

Performance on subjective measures

Patients with PD reported significantly more problems in EFs on the DEX, BAFQ, and BDEFS – time management questionnaires than did controls, which is consistent with the large effect sizes (see table 2). Comparison of patients' evaluations with those of their relatives showed that patients reported significantly more complaints on the BDEFS – time management questionnaire (table 3). Differences between patients and relatives on the other questionnaires were not significant. Furthermore, all subjective measures of EFs were moderately to strongly interrelated (DEX and BDEFS – time management: $r = .45$, $P = .004$; DEX and BAFQ: $r = .79$, $P < .001$; BDEFS – time management and BAFQ: $r = .57$, $P < .001$).

Association between objective and subjective measures of EFs

No significant correlations were found between any of the performances on the objective and subjective measures of EFs (table 4).

Contribution of objective and subjective measures of EFs to level of participation and QoL

Within the patient group, no significant correlations were found between the objective test measures and the IPA scale and PDQ-39. The subjective measures DEX, BDEFS – time management, and BAFQ, however, were all significantly related to the PDQ-39

Table 3 Scores on questionnaires of patients with PD and their relatives (proxy rating)

Questionnaire	Self-Rating (n=42)	Proxy Rating (n=40)	Paired-Sample <i>t</i> Test		Effect Size (<i>d</i>)
			<i>t</i>	<i>P</i>	
DEX	26.29±10.82	22.02±13.59	2.18	.035	.35
BAFQ	2.26±0.39	2.12±0.51	2.33	.026	.31
BDEFS-tm	45.21±12.24	40.29±14.96	2.82	.008*	.36

NOTE. Values are mean ± SD or as otherwise indicated.

Abbreviation: BDEFS-tm, Barkley Deficits in Executive Functioning Scale — time management.

* *P* value was less than Bonferroni-corrected α .

(see table 4). Furthermore, the scores on the IPA scale were significantly associated with the scores on the BDEFS — time management and BAFQ (see table 4). For subsequent regression analyses, the objective and subjective measures that showed the highest mean correlation with the dependent variables (ie, IPA scale and PDQ-39) were included as independent variables (ie, BADS Zoo Map subtest and BAFQ) in the model (see table 4).

The regression model explained 78% of variance of the total score on the IPA scale ($F=7.06$, $P<.001$). Age, sex, BADS Zoo Map total score, and BAFQ total score were significant predictors (table 5). Hence, for patients with PD, a combination of a higher age, being female, a better BADS Zoo Map score, but more complaints as measured using the BAFQ were related to a higher IPA scale score (ie, a lower level of participation). For the PDQ-39, the results showed that the model explained 68% of variance ($F=4.13$, $P=.004$). Significant predictors were sex, Unified Parkinson's Disease Rating Scale part III total score, and BAFQ total score (see table 5). Hence, the combination of being female, showing more severe PD-related motor symptoms, and reporting more problems on the BAFQ was related to a higher score on the PDQ-39 (ie, a reduced QoL) in patients with PD.

Discussion

The objective and subjective measures of EFs are each good predictors of level of participation in daily life and QoL in patients with mild to moderate PD. Both types of measurement indicate that patients with PD show difficulties in EFs, but without being significantly related to each other. On subjective measures,

patients reported significantly more complaints than did controls without PD, which is in line with previous studies.^{17,18,22} Compared with their relatives, patients reported more problems in executive functioning related to time management (BDEFS — time management). Because the BDEFS — time management questionnaire includes questions related to time management, initiation of behavior, and distractibility, this suggests that patients are bothered with time management issues, initiation difficulties, and feelings of distraction that are not (yet) observed by their relatives, a finding that is consistent with the study of Lanni et al.²⁴ With regard to all the other questionnaires of EFs, no differences were found between self- and proxy ratings. Thus, patients and their relatives in general agree on the EF problems as experienced by patients in daily life. This has also been found in recent studies and supports the idea that patients with PD do not have impaired self-awareness, which is usually indicated by lower scores of patients compared to their relatives and thus underestimation of problems.^{4,18,22}

With regard to objective neuropsychological tests, patients with PD showed a higher percentage of impairments than did controls on 3 of 5 tests of EFs, which is consistent with the fact that impairments in EFs occur in PD.^{2,30,31} However, when directly comparing patients with PD with controls without PD, patients with PD performed significantly worse only on the Visual Elevator Test, but not on other neuropsychological tests. In this context, a relatively mild group of patients with PD was included in the present study.

Notwithstanding these findings, we found no significant associations between objective and subjective measures of EFs, replicating previous studies.^{18,22,24,32} Apparently, test results do

Table 4 Pearson correlations between objective and subjective measures of EFs and measures of participation and QoL

Measure	DEX	<i>P</i>	BDEFS-tm	<i>P</i>	BAFQ	<i>P</i>	IPA	<i>P</i>	PDQ-39	<i>P</i>
Objective										
TMT B/A	-.03	.856	.20	.222	.14	.381	.17	.314	-.04	.793
Stroop 3/2	-.32	.042	-.22	.185	-.30	.062	-.04	.825	-.09	.566
Visual Elevator Test	-.04	.804	-.08	.623	-.05	.781	-.03	.880	-.15	.361
Verbal Fluency Test	.02	.908	.07	.692	-.18	.280	.04	.834	.03	.878
BADS Zoo Map	.23	.140	.15	.368	.15	.350	.34	.033	-.18	.262
Subjective										
DEX	NA	NT	NT	NT	NT	NT	.32	.045	.39	.011*
BDEFS-tm	NT	NT	NA	NT	NT	NT	.42	.007*	.47	.003*
BAFQ	NT	NT	NT	NT	NA	NT	.51	.002*	.42	.008*

Abbreviations: BADS Zoo Map, Behavioural Assessment of the Dysexecutive Syndrome Zoo Map subtest; BDEFS-tm, Barkley Deficits in Executive Functioning Scale — time management; NA, not applicable; NT, not tested; Stroop 3/2, Stroop Color-Word/Color card ratio; TMT B/A, Trail Making Test B/A ratio.

* Significant *P* value was less than Bonferroni-corrected α .

Table 5 Results of the multiple regression analyses for the prediction of level of participation (IPA) and QoL (PDQ-39) in patients with PD

Measure	B	β	t	P
IPA				
Constant	-30.81	NA	-3.28	.003*
Age	0.22	.35	2.68	.012†
Sex	6.59	.52	3.72	.001*
UPDRS part III score	-0.01	-.02	-0.16	.874
HADS total score	0.01	.01	0.07	.944
BADS Zoo Map total score	0.46	.37	2.92	.007*
BAFQ score	10.81	.73	3.61	.001*
PDQ-39				
Constant	-40.42	NA	-1.11	.275
Age	-0.16	-.08	-0.52	.606
Sex	18.63	.43	2.72	.011†
UPDRS part III score	0.70	.32	2.25	.032†
HADS total score	0.24	.06	0.30	.767
BADS Zoo Map total score	-1.00	-.24	-1.66	.107
BAFQ score	28.27	.57	2.44	.021†

Abbreviations: B, unstandardized coefficient; β , standardized coefficient; BADS Zoo Map, Behavioural Assessment of the Dysexecutive Syndrome Zoo Map subtest; NA, not applicable; UPDRS part III, Unified Parkinson's Disease Rating Scale motor part.

* $P < .01$.

† $P < .05$.

not correspond to complaints about EFs, indicating that objective and subjective assessments measure performance at different levels. A possible explanation for this discrepancy is that standard neuropsychological tests of EFs have a limited ecological validity, because these tests are structured, are standardized, and have clearly defined start and endpoints that are not available in daily life. This argument cannot, however, explain the nonsignificant association between the BADS Zoo Map score and the scores on the other questionnaires, because the BADS is considered to have a relatively high ecological validity. A better explanation might be that in addition to aspects of EFs, such as planning and monitoring of behavior, that are measured with neuropsychological tests, questionnaires measure behavioral and social-emotional aspects. For instance, self-initiation of behavior, empathy, impulsive behavior, and social monitoring are hard to objectify with neuropsychological tests, but can be assessed with questionnaires. Finally, the fact that both approaches measure EFs at different levels might also be of influence; objective tests target patients' optimal performance, whereas questionnaires ask patients to give their view on normal functioning in daily life.²⁶

To determine to what extent objective and subjective assessments of EFs can predict level of participation and QoL in patients with PD, regression analyses were conducted. The combination of a higher age, being female, a better performance on an objective test of EFs (BADS Zoo Map subtest), and reporting more complaints about EFs in daily life was related to a significant reduction in level of participation (within the domains of household activities and social relations). Higher age having a negative influence on patients' level of participation might be explained by aging, usually involving a reduction of social relations and increase in health problems, which can hamper, for example, the performance of household activities.

In previous studies on sex in relation to participation and QoL, female patients with PD tend to report greater disability, a stronger

reduction in social functioning, and a lower perceived QoL as compared with male patients,^{33,34} which is in line with our findings. Furthermore, our results show that EFs were associated with patients' participation level. However, contrary to what might be expected, we found that a better performance of objectively measured impairments in EFs was associated with a lower level of participation. Even though the contribution of the performance of the objective test of EFs to the level of participation should be considered in the context of all other variables, there is no clear explanation for this finding. It could be that patients with a sufficient score on the BADS Zoo Map subtest (that is not indicative of impairment) have an intact self-awareness and therefore tend to notice more problems in daily life functioning, which, in turn, leads to a lower level of participation⁹; however, this finding might also be based on chance. Level of participation was also predicted by subjective complaints (BAFQ). Reported complaints about EFs are thus related to a decreased participation in daily life of patients with PD, which supports the conclusions of a previous study.³⁵

The combination of being female, showing more severe PD-related motor symptoms, and reporting more complaints about EFs was associated with a reduced QoL in patients. Interestingly, disease severity appeared to be a significant predictor of QoL, which is in line with a previous study,³⁶ but it was not related to participation. In addition, just as for participation level, sex differences and subjective complaints about EFs were found to be significant predictors of QoL. It is not surprising that subjective complaints were a significant predictor of QoL, because these also reflect the burden associated with impairments in EFs, which, in turn, will negatively influence the QoL of patients. This strengthens the idea that sex differences and subjective complaints about EFs are important aspects that need to be taken into account when determining patients' level of participation and QoL.

Study limitations

A limitation of the present study is that more severely affected patients with PD (ie, Hoehn and Yahr scale, stage 4 and 5) were not included. It could be that more severely affected patients show and report more or other EF impairments and that their level of participation and QoL are predicted by different aspects. Furthermore, the heterogeneity of the patient group with regard to treatment (ie, dopaminergic treatment and deep brain stimulation; $n=2$) is a limitation. Regarding dopaminergic treatment, this is inherent to PD, and on ethical grounds it was not possible to adjust patients' medication for research purposes. Furthermore, recent literature states that there is no convincing evidence for the assumption that deep brain stimulation leads to impairments in cognitive functioning.³⁷ Given that patients with severe cognitive impairments were excluded, including 2 patients who underwent deep brain stimulation most likely did not influence the results.

Conclusions

Impairments in EFs that patients with mild to moderate PD show during the objective assessment are not related to complaints about EFs in daily life. Both objective and subjective measures can, however, predict patients' level of participation. In addition, subjective measures explained a significant part of QoL. These findings indicate that the objective and subjective approaches are not interchangeable and each has a unique contribution to the

assessment of problems in executive functioning and to the prediction of participation and QoL in patients with PD. Moreover, sex differences need to be taken into account. On the basis of these findings, we suggest to include ≥ 1 objective and subjective measures of EFs as a standard part of assessment in patients with PD so as to recognize even mild deficits in EFs early and to allow offering patients early interventions for these problems. This may foster maintaining patients' level of participation in daily life and related QoL for a longer period, despite the progression of the disease.

Keywords

Executive function; Neuropsychological tests, Parkinson disease; Quality of life; Rehabilitation; Social participation

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