Measuring quality of life with the Parkinson’s Disease Questionnaire-39 in people with cognitive impairment

Aline Schönenberg 1*, Tino Prell 1,2,3

1 Department of Geriatrics, Halle University Hospital, Halle, Germany, 2 Department of Neurology, Jena University Hospital, Jena, Germany, 3 Center for Healthy Ageing, Jena University Hospital, Jena, Germany

* aline.schoenberg@uk-halle.de

Abstract

Introduction
Quality of life (QoL) is a key outcome in healthcare. However, whether cognitively impaired people with Parkinson’s disease (PD) can reliably self-report QoL is unclear, and patients are often excluded from studies based on cognition test scores. The aim of this analysis was to assess the validity of the Parkinson’s Disease Questionnaire-39 (PDQ-39) in PD patients with and without cognitive impairment.

Methods
In this study, 221 individuals with PD completed the PDQ-39, Montreal Cognitive Assessment (MOCA), and Beck’s Depression Inventory (BDI-II). The PDQ-39’s internal consistency, convergent validity with BDI-II, and floor and ceiling effects were analyzed for patients with and without cognitive impairment.

Results
Ninety-four patients showed cognitive impairment (MOCA < 21), whereas 127 patients had mild/no impairment. Both MOCA groups differed significantly with regards to PD severity. The PDQ-39’s internal consistency was adequate for most subdomains in both MOCA groups, but floor effects were present for the subdomains Stigmatization, Social Support and Communication, regardless of impairment. For some subdomains, the PDQ-39’s convergent validity with the BDI receded in the low MOCA group but remained significant for most PDQ-39 domains, especially for the PDQ total score (r = .386, p < .001) and for the subdomain emotional well-being (r = .446, p < .001).

Conclusion
The PDQ-39 can be used to measure QoL in cognitively impaired PD patients, thus test scores indicating cognitive impairment alone should not lead to exclusion of PD patients from clinical studies. Although the correlation between BDI-II and PDQ-39 shrinks for some subdomains in cognitively impairment patients, this finding may be explained by the
Introduction

Health-related quality of life (QoL) describes a patient’s interpretation of their current health and is a key outcome in healthcare, especially for chronic neurodegenerative disorders, including Parkinson’s disease (PD). Nonmotor symptoms have one of the greatest influences on QoL in patients with PD, with depression alone accounting for a large amount of the variability in QoL [1, 2]. Although different QoL instruments have been validated [2], whether cognitively impaired patients can reliably self-report QoL remains unclear. There are QoL instruments specifically constructed for cognitively impaired patients, however, the use of these instrument in both clinical and research settings is limited due to unavailability and difficulties regarding feasibility (e.g. costs, duration, scoring), or lack of psychometric characteristics [3]. Additionally, results may vary with severity of cognitive deficits [4, 5]. As PD is a progressive disease with characteristic symptoms, the use of a disease-specific QoL instrument is often reasonable and necessary [6]. Of those specific instruments, the PD Questionnaire-39 (PDQ-39) is most widely used [6, 7]. Given the high prevalence of cognitive deficits in PD [8, 9], it is important to assess whether PD patients with cognitive deficits can make reliable statements about their QoL using the PDQ-39. This is crucial for both health practice and research to ensure that patients are not unnecessarily excluded from clinical research based on cognitive impairment scores alone.

QoL ratings provided by relatives or caregivers do not capture the patients’ evaluations and rate QoL systematically lower than the patients themselves, and previous research suggests that patients can make reliable statements about QoL up into late stages of dementia [10]. Whether those differences between self-reports and proxy ratings stem from low reliability of patient or proxy ratings remains unclear [4]; thus, we decided to not compare self-reported QoL with proxy assessments. Instead, we assessed the validity of QoL assessments in patients with PD with and without cognitive impairment using the well-documented relationship between QoL and depression [1, 2].

For this purpose, internal consistency of the PDQ-39 was assessed for patients with and without cognitive impairment, and convergent validity was examined with depression questionnaires.

Methods

Participants and assessments

This manuscript provides an additional analysis of an existing dataset, thus details on the data collection procedure and demographic and clinical data regarding PD severity are given elsewhere [11]. This study was approved by the Ethics Committee of Jena University Hospital and conducted according to the Declaration of Helsinki. A total of 230 inpatients with PD were recruited from January 2019 to January 2020 from the Department of Neurology, Jena University Hospital, Germany. Inclusion criteria consisted of PD as a primary diagnosis as well as absence of severe dementia and delirium. Because of missing data in the measures used for this additional manuscript, nine patients were excluded from the analysis, leaving 221 datasets. Since there are no sample size guidelines for content validation and sample sizes vary across the literature, our estimation was based on the recommended sample size of a minimum of...
100 patients for construct validation studies, with recommendations varying between 100 and 250 [12].

All patients or legal representatives provided written informed consent. Data were collected by trained research staff, and tests were performed at the hospital during medication on-phase. PD diagnosis was made by a trained neurologist according to the Movement Disorder Society (MDS) criteria. Cognition was assessed using the Montreal Cognitive Assessment (MOCA) [13] in face-to-face testing, enabling us to gather an impression of each patient’s ability to understand and complete a questionnaire. Therefore, we included patients with MOCA scores below the threshold of 21 points for PD dementia (PDD) [14] if they could answer the questions coherently. Accordingly, the cohort was split into two groups: low MOCA (<21 points) and high MOCA (≥21 points). For a more refined analysis, the cohort was additionally split into three groups (MOCA <21, MOCA 21–25, MOCA ≥26) to confirm the results.

QoL was assessed using the PDQ-39, a self-report questionnaire depicting the frequency of impairments on a 4-point Likert scale ranging from “Never” to “Always”. The PDQ-39 can be summarized in a total score as well as eight subdomains regarding mobility, activities of daily living (ADL), emotional well-being, stigmatization, social support, cognition, communication, and bodily discomfort, with higher scores indicating more frequent impairment in these domains [7].

Beck’s Depression Inventory-II (BDI-II) was used to assess depression. The BDI-II assesses the severity of depressive symptoms across 21 self-report items cumulating in an overall sum score, with higher scores indicating higher severity [15].

Additionally, the non-motor symptom questionnaire (NMS-Q) [16] was used to confirm the results of the comparison with the BDI. Of note, although the NMS-Q includes questions regarding mental well-being, it assesses a wide range of non-motor symptoms and is not focused on mental well-being, thus the results are reported in the supplementary materials as an additional indicator. Physical functioning was assessed with the Movement Disorder Society MDS-Unified Parkinson’s Disease Rating Scale (UPDRS), an assessment performed by trained medical staff evaluating the severity of common nonmotor and motor symptoms of PD [17]. Again, higher scores indicate more severe symptoms.

**Statistical analysis**

Statistical analyses were performed using Statistical Package for the Social Sciences (version 27.0; IBM Corp., Armonk, NY, USA) and R (version 4.1.1; R Foundation for Statistical Computing, Vienna, Austria). P-values below 0.05 denote statistical significance.

Initially, the cohort was analyzed using descriptive statistics (mean, ± standard deviation (SD), and percentages), and normal distribution was assessed with the Shapiro–Wilk test. Group comparisons were performed with Mann–Whitney U test for metric variables using the R-Package *rstatix* [18], and the chi-square test for categorical variables. The 95% confidence intervals and effect sizes are given where applicable. Effect sizes for group comparisons (two-sample rank-sum tests) are calculated by dividing the z statistic by the square root of the sample size and can be interpreted as small effects (0.10 - < 0.3), moderate effects (0.30 - < 0.5) and large effects (≥ 0.5) [18].

To assess the reliability of the PDQ-39, scores and internal consistency were assessed for both MOCA groups. Floor and ceiling effects describe the proportion of patients reaching the highest (ceiling) or lowest (floor) possible score and were considered present if at least 15% of the respondents reached this respective score. Internal consistency was measured using Cronbach’s alpha and considered adequate for values higher than 0.70 [19]. Convergent validity was assessed with the Spearman correlation of all PDQ-39 domains with the BDI-II.
Recommendations indicate that correlations between instruments measuring similar constructs should be greater than or equal to 0.5, thus a correlation of 0.5 was expected between the BDI-II and the PDQ-39 subscale emotional well-being. For instruments measuring similar but not identical constructs, correlation should lie between 0.3 and 0.5. Correlations of 0.1, 0.3, and 0.5 were considered weak, moderate, and strong correlations, respectively [19].

Results
The cohort (N = 221) included 89 (40.3%) female and 132 (59.7%) male PD patients between the age of 40 and 89 (mean 70.81 ± 8.32) years. Ninety-four patients (42.5%) had low MOCA scores (<21 points), and 127 patients (57.5%) had high MOCA scores (≥21 points) (S1 Fig).

Detailed clinical and demographic data are shown in Table 1.

Significant differences in BDI-II score (p = 0.005), PDQ-39 total score (p = 0.001), age (p < 0.001), HY stages (p = 0.001), NMS-Q score (p = 0.001), and MDS-UPDRS score (p = 0.013) were observed between the two MOCA groups (Table 1). Considering the PDQ-39 subdomains, patients in the low MOCA group scored worse in mobility (p = 0.004), activities of daily living (p = 0.001), emotional well-being (p = 0.002), social support (p = 0.002), cognition (p = 0.011), and communication (p = 0.047) (see also S2 Fig).

Floor effects were present for the PDQ-39 subdomains stigmatization, social support, and communication for both MOCA groups. Internal consistency was adequate and comparable between groups for most PDQ-39 subdomains (Table 2).

To estimate the convergent validity of the PDQ-39, we correlated each subdomain to the BDI-II total score (Table 3). In the high MOCA group, all PDQ-39 subdomains and the total score showed moderate to high correlations with the BDI-II. For patients with low MOCA scores, correlations remained comparable, although they were slightly lower for some subdomains. However, the PDQ-39 total score and all subdomains, except for stigmatization and bodily discomfort, continued to show moderate, significant correlation with the BDI-II.

Discussion
We conducted this study to assess the accuracy of the PDQ-39 in PD patients with low and high MOCA scores and examine whether cognitively impaired individuals with PD can make reliable self-report statements about their QoL. Certain instruments have been validated to assess cognitively impaired persons, but they are not widely used and results may vary across cohorts and instruments [2, 4]. Proxy ratings of QoL for older adults are not reliable sources of information on the patients’ QoL assessments [4] and validity assessments of instruments may vary depending on cohort factors and choice of comparison instruments [2]. Thus, there is no gold standard QoL instrument for convergent validity assessments.
Overall, our results indicate that the responses to the PDQ-39 are reliable for PD patients with lower MOCA scores in most PDQ-39 subdomains. Of note, our lowest MOCA score was 12 points. Therefore, we cannot make statements about the accuracy below this threshold.

### Table 1. Clinical and demographic data of people with low and high MOCA scores.

| MOCA < 21 | MOCA ≥ 21 | p | Φ |
|-----------|-----------|---|---|
| **Sex** | | | |
| female | 42 (44.7) | 47 (37.0) | .312 | .08 |
| male | 52 (55.3) | 80 (63.0) | | |
| **Education level** | | | |
| low | 26 (32.9) | 15 (12.9) | .003 | .250 |
| middle | 21 (26.6) | 46 (39.7) | | |
| high | 32 (40.1) | 55 (47.4) | | |
| **Mean (SD) Median (IQR)** | | | |
| Age (y) | 73.80 (8.12) 75 (9) | 68.60 (7.80) 69 (10) | <.001 | .350 |
| Disease duration (y) | 7.96 (5.76) 7 (7) | 7.30 (5.37) 6 (8) | 0.405 | .056 |
| Hoehn and Yahr | 3 (1) | 3 (1) | | |
| MDS-UPDRS | 76.20 (27.60) (42) | 62.10 (28.20) 62 (39) | .013 | .237 |
| NMS-Quest | 12.10 (4.82) 12 (8) | 9.90 (5.00) 9 (7) | .001 | .223 |
| BDI-II | 14.30 (7.72) 13 (9) | 12.2 (8.87) 10 (9) | .005 | .186 |
| MOCA | 17.29 (2.98) 18 (3) | 24.20 (2.36) 24 (4) | <.001 | .857 |
| PDQ-39 | 34.60 (15.80) 35 (23) | 27.40 (16.90) 27 (26) | .001 | .225 |
| Mobility | 48.76 (26.70) 48 (37.5) | 37.88 (27.59) 31 (48) | .004 | .192 |
| ADL | 41.48 (25.23) 42 (44.8) | 30.90 (25.28) 25 (38) | .001 | .217 |
| EWB | 36.84 (20.80) 38 (28) | 28.09 (22.51) 25 (38) | .002 | .207 |
| Stigmatization | 21.87 (19.72) 19 (32) | 20.02 (22.18) 12 (31) | .214 | .084 |
| Social Support | 21.62 (22.36) 17 (33) | 13.02 (18.76) 0 (17) | .001 | .209 |
| Cognition | 36.50 (29.32) 38 (25) | 30.08 (22.67) 25 (32) | .011 | .171 |
| Communi-cation | 30.65 (21.85) 33 (25) | 25.13 (23.83) 17 (42) | .047 | .134 |
| Bodily Discomfort | 38.85 (22.61) 42 (25) | 34.82 (24.48) 33 (33) | .164 | .094 |

MDS-UPDRS: MDS-sponsored revision of the unified PD rating scale, NMS-Quest: Nonmotor-Symptoms Questionnaire, BDI II = Beck’s Depression Inventory, PDQ-39: Parkinson’s Disease Questionnaire 39, MOCA: Montreal Cognitive Assessment. p depicts significant difference between mean scores for each domain based on Mann-Whitney U test or Chi² test, r depicts the effect size of this comparison based on two-sample rank-sum test, Φ = Phi.

Overall, our results indicate that the responses to the PDQ-39 are reliable for PD patients with lower MOCA scores in most PDQ-39 subdomains. Of note, our lowest MOCA score was 12 points. Therefore, we cannot make statements about the accuracy below this threshold. As

### Table 2. Parkinson’s Disease Questionnaire-39 scores and internal consistency in people with low and high Montreal Cognitive Assessment scores.

| PDQ-39 Scale | MOCA < 21 | MOCA ≥ 21 | |
|--------------|-----------|-----------|---|
| Floor | Ceiling | α | Floor | Ceiling | α |
| PDQ-39 sum | 0 | 0 | 0 | 0 | |
| Mobility | 5.3 | 0 | 0.927 | 4.7 | 1.6 | 0.942 |
| Activities of daily living | 7.4 | 0 | 0.882 | 6.3 | 0.8 | 0.898 |
| Emotional well-being | 3.2 | 0 | 0.864 | 12.6 | 0.8 | 0.900 |
| Stigmatization | 22.3 | 0 | 0.775 | 31.5 | 0 | 0.823 |
| Social support | 34.0 | 0 | 0.70 | 51.2 | 0 | 0.681 |
| Cognition | 7.4 | 0 | 0.737 | 10.2 | 0.8 | 0.783 |
| Communication | 18.1 | 0 | 0.719 | 23.8 | 0.8 | 0.794 |
| Bodily discomfort | 8.5 | 0 | 0.637 | 12.6 | 0 | 0.675 |

PDQ-39: Parkinson’s Disease Questionnaire-39; BDI-II: Beck’s Depression Inventory-II, MOCA: Montreal Cognitive Assessment.; α = Cronbach’s Alpha.

Overall, our results indicate that the responses to the PDQ-39 are reliable for PD patients with lower MOCA scores in most PDQ-39 subdomains. Of note, our lowest MOCA score was 12 points. Therefore, we cannot make statements about the accuracy below this threshold. As
expected, we observed moderate to strong associations between depression and PDQ-39 sub-domains cognition and emotional well-being subdomains, which are both primarily related to mood [1, 2, 20]. The subdomains stigmatization, communication, and social support showed floor effects; and as confirmed by other studies, the social support and bodily discomfort subdomains also had below adequate internal consistency, indicating that some subdomains may not have been appropriate in both MOCA groups [7, 21]. For this reason, Cronbach’s Alpha for those domains should be interpreted with caution. However, it is neither the intention nor in the scope of this analysis to judge the adequacy of the PDQ. In addition, internal consistency and floor effects were comparable between PD patients with high and low MOCA scores, indicating that cognitive impairment was not responsible for these responses.

Although convergent validity remained comparable for most subdomains in the low MOCA group, some subdomains showed changes compared to the high MOCA group, indicating that the association between the instruments shifts with increasing cognitive impairment. This seems reasonable as, comparable to other studies [22, 23], the PD patients in the low MOCA group were older and scored worse in HY stages, MDS-UPDRS, and NMS-Q, which all have an additional influence on QoL. Thus, the changing association between PDQ-39 and BDI-II in the low MOCA group may be influenced by shifting QoL due to advanced age and disease progression that may not be fully captured by all instruments [1, 2]. The BDI-II and PDQ-39 do not aim to measure the exact same constructs, and although the BDI-II can capture certain aspects of QoL [15] as mood plays a pivotal role [1, 2], it is intended that the PDQ-39 encompasses symptoms not registered by the BDI-II. Emotional well-being and cognition, two PDQ-39 subdomains related primarily to mood [20], show significant correlation with the BDI-II even in the low MOCA group, whereas other domains not primarily assessed by the BDI-II changed in correlation, suggesting that the impact of those symptoms exceeds the scope of the BDI-II at a certain severity stage.

Regarding the characteristics of the described cohort, we thus considered the correlation between BDI-II and PDQ-39 scores in the low MOCA group to be expected. As most subdomains still show comparable internal consistency and appropriate convergent validity for instruments measuring similar but not identical constructs [19], we conclude that the PD patients in our cohort with MOCA scores below the cutoff of 21 for PDD can reliably self-report QoL using the PDQ-39. As the BDI-II does not capture all aspects of QoL and cannot encompass all PDQ-39 subdomains, further studies are needed to validate the QoL assessment

| PDQ-39   | MOCA < 21 | MOCA ≥ 21 |
|----------|-----------|-----------|
|          | Spearman  | P         | 95% CI   | Spearman  | P         | 95% CI   |
| PDQ-39 total score | 0.386 | <0.001 | .199, .546 | 0.50 | <0.001 | .39, .64 |
| Mobility | 0.265 | .01 | .065, .444 | .281 | .001 | .113, .434 |
| Activities of daily living | .250 | .015 | .050, .430 | .331 | <0.001 | .166, .477 |
| Emotional well-being | 0.446 | <0.001 | .267, .595 | 0.634 | <0.001 | .517, .728 |
| Stigmatization | 0.133 | 0.203 | -0.072, .326 | 0.257 | 0.004 | .086, .413 |
| Social support | 0.400 | <0.001 | .215, .558 | .282 | 0.001 | .114, .435 |
| Communication | 0.274 | 0.008 | .076, .452 | 0.613 | <0.001 | .491, .711 |
| Bodily discomfort | 0.158 | 0.129 | -0.046, .349 | 0.295 | 0.001 | .128, .447 |

PDQ-39, Parkinson’s Disease Questionnaire-39; BDI-II, Beck’s Depression Inventory-II; MOCA, Montreal Cognitive Assessment.
of cognitively impaired individuals using other QoL instruments. Overall, we conclude that a low score in cognitive impairment measures alone should not be a reason to exclude PD patients from clinical studies on QoL.

This study is not without limitations. The cross-sectional design does not allow for interpretations of causality, and the sample of PD patients restricts generalization across other cohorts, not allowing any conclusions for overall QoL assessment in persons with cognitive impairment not suffering from PD. Lastly, although we included patients with MOCA scores below the cutoff for PDD, we did not include patients with severely impaired cognition, as filling in a questionnaire is impossible in such cases, but see [23] for an assessment of QoL in patients with PDD. Notably, the MOCA alone cannot replace a comprehensive neuropsychological assessment of cognition and does not represent an actual diagnosis of cognitive impairment; however, the MOCA or comparable measures are often used in clinical studies to exclude patients below a certain cut-off, leading to an underrepresentation of these patients and their needs in clinical studies. Although a first statement can be made that these PD patients should not be excluded solely on the basis of such MOCA scores, more studies are needed to elucidate the measurement of QoL in patients with varying degrees of cognitive impairment, e.g. assessing test-retest reliability or utilizing several QoL instruments for comparison. Another promising route to assessing the usability of the PDQ-39 in PD patients with cognitive impairment is its strong relationship with anxiety, as anxiety is also highly prevalent in PD and just as debilitating for QoL [2, 24]. Thus, in future studies, similar analyses should be performed using anxiety as another measure for convergent validity. Additionally, more research is needed to understand the use of QoL measures in cognitively impaired patients without PD.

**Supporting information**

S1 Fig. Frequency of Montreal cognitive assessment (MOCA) total scores. (DOCX)

S2 Fig. PDQ-39 responses for persons with low and high MOCA (mean with standard deviation). (DOCX)

S1 Table. BDI Responses for persons with low and high MOCA. (DOCX)

S2 Table. Convergent validity of the PDQ-39 for people with varying levels of cognitive impairment. (DOCX)

S3 Table. Convergent validity of the PDQ-39 and the NMS-Q for people with low and high MOCA score. (DOCX)

S4 Table. Convergent validity of the PDQ-39 and the UPDRS for people with low and high MOCA score. (DOCX)

**Acknowledgments**

We thank Eric Winter and Caroline Kamprath for their assistance in data acquisition.
Author Contributions

Conceptualization: Aline Schönenberg, Tino Prell.

Formal analysis: Aline Schönenberg, Tino Prell.

Writing – original draft: Aline Schönenberg.

Writing – review & editing: Tino Prell.

References

1. Sławek J, Derejko M, Lass P. Factors affecting the quality of life of patients with idiopathic Parkinson’s disease—a cross-sectional study in an outpatient clinic attendees. Parkinsonism Relat Disord. 2005; 11 (7):465–8. Epub 2005/09/13. https://doi.org/10.1016/j.parkreldis.2005.04.006 PMID: 16154794.

2. Zhao N, Yang Y, Zhang L, Zhang Q, Balbuena L, Ungvari GS, et al. Quality of life in Parkinson’s disease: A systematic review and meta-analysis of comparative studies. CNS neuroscience & therapeutics. 2021; 27(3):270–9. Epub 2020/12/30. https://doi.org/10.1111/cns.13549 PMID: 33372386; PubMed Central PMCID: PMC7871788.

3. Hughes LJ, Farina N, Page TE, Tabet N, Banerjee S. Psychometric properties and feasibility of use of dementia specific quality of life instruments for use in care settings: a systematic review. Int Psychogeriatr. 2021; 33(9):917–31. Epub 20190103. https://doi.org/10.1017/S1041610218002259 PMID: 30602403.

4. Ettema TP, Dröes RM, de Lange J, Mellenbergh GJ, Ribbe MW. A review of quality of life instruments used in dementia. Quality of life research: an international journal of quality of life aspects of treatment, care and rehabilitation. 2005; 14(3):675–86. Epub 2005/07/19. https://doi.org/10.1007/s11136-004-1258-0 PMID: 16022061.

5. Landeiro F, Mughal S, Walsh K, Nye E, Morton J, Williams H, et al. Health-related quality of life in people with pre dementia Alzheimer’s disease, mild cognitive impairment or dementia measured with preference-based instruments: a systematic literature review. Alzheimers Res Ther. 2020; 12(1):154. Epub 20201118. https://doi.org/10.1186/s13195-020-00723-1 PMID: 33208190; PubMed Central PMCID: PMC7677851.

6. Martinez-Martin P, Jeukens-Visser M, Lyons KE, Rodriguez-Blazquez C, Selai C, Siderowf A, et al. Health-related quality-of-life scales in Parkinson’s disease: critique and recommendations. Mov Disord. 2011; 26(13):2371–80. Epub 20110706. https://doi.org/10.1002/mds.23834 PMID: 21735480.

7. Peto V, Jenkinson C, Fitzpatrick R. PDQ-39: a review of the development, validation and application of a Parkinson's disease quality of life questionnaire and its associated measures. J Neurol. 1998;245 Suppl 1:S10-4. Epub 1998/06/09. https://doi.org/10.1007/p100007730 PMID: 9617716.

8. Aarsland D, Kurz MW. The epidemiology of dementia associated with Parkinson disease. J Neurol Sci. 2010; 289(1–2):18–22. Epub 20090904. https://doi.org/10.1016/j.jns.2009.08.034 PMID: 19733364.

9. Nicoletti A, Luca A, Baschi R, Cicero CE, Mostile G, Davì M, et al. Incidence of Mild Cognitive Impairment and Dementia in Parkinson’s Disease: The Parkinson’s Disease Cognitive Impairment Study. Frontiers in Aging Neuroscience. 2019;11. https://doi.org/10.3389/fnagi.2019.00011 PMID: 30837862.

10. Schönlau-Dorenbos CJ, Ettema TP, Bos J, Boelens-van der Knoop E, Gerritsen DL, Hoogeveen F, et al. Evaluating the outcome of interventions on quality of life in dementia: selection of the adequate scale. Int J Geriatr Psychiatry. 2007; 22(6):511–9. https://doi.org/10.1002/gps.1719 PMID: 17133965.

11. Schönberg A, Zipprich HM, Teschner U, Grosskreutz J, Witte OW, Prell T. Impact of subthreshold depression on health-related quality of life in patients with Parkinson’s disease based on cognitive status. Health and quality of life outcomes. 2021; 19(1):107. Epub 2021/03/27. https://doi.org/10.1186/s12955-021-01753-5 PMID: 33766054; PubMed Central PMCID: PMC7993461.

12. Anthoine E, Moret L, Regnauld A, Sébille V, Hardouin JB. Sample size used to validate a scale: a review of publications on newly-developed patient reported outcomes measures. Health and quality of life outcomes. 2014; 12:176. Epub 2014/12/11. https://doi.org/10.1186/s12955-014-0176-2 PMID: 25492701; PubMed Central PMCID: PMC4275948.

13. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. Journal of the American Geriatrics Society. 2005; 53(4):695–9. Epub 2005/04/09. https://doi.org/10.1111/j.1532-5415.2005.53221.x PMID: 15817019.
14. Dalrymple-Alford JC, MacAskill MR, Nakas CT, Livingston L, Graham C, Crucian GP, et al. The MoCA: well-suited screen for cognitive impairment in Parkinson disease. Neurology. 2010; 75(19):1717–25. https://doi.org/10.1212/WNL.0b013e3181fc29c9 PMID: 21060094.

15. Visser M, Leentjens AF, Marinus J, Stiggelbout AM, van Hilten JJ. Reliability and validity of the Beck depression inventory in patients with Parkinson’s disease. Mov Disord. 2006; 21(5):668–72. Epub 2006/02/02. https://doi.org/10.1002/mds.20792 PMID: 16450355.

16. Romenets SR, Wolfson C, Galatas C, Pelletier A, Altman R, Wadup L, et al. Validation of the non-motor symptoms questionnaire (NMS-Quest). Parkinsonism Relat Disord. 2012; 18(1):54–8. Epub 2011/09/16. https://doi.org/10.1016/j.parkreldis.2011.08.013 PMID: 21917501.

17. Goetz CG, Fahn S, Martinez-Martin P, Poewe W, Sampaio C, Stebbins GT, et al. Movement Disorder Society-sponsored revision of the Unified Parkinson’s Disease Rating Scale (MDS-UPDRS): Process, format, and clinimetric testing plan. Mov Disord. 2007; 22(1):41–7. Epub 2006/11/23. https://doi.org/10.1002/mds.21198 PMID: 17115387.

18. Kassambara A. rstatix: Pipe-Friendly Framework for Basic Statistical Tests. R package version 0.7.0. 2021.

19. Prinsen CAC, Mokkink LB, Bouter LM, Alonso J, Patrick DL, de Vet HCW, et al. COSMIN guideline for systematic reviews of patient-reported outcome measures. Quality of life research: an international journal of quality of life aspects of treatment, care and rehabilitation. 2018; 27(5):1147–57. Epub 2018/02/13. https://doi.org/10.1007/s11136-018-1796-3 PMID: 29435801; PubMed Central PMCID: PMC5891568.

20. Jones JD, Hass C, Mangal P, Lazo J, Okun MS, Bowers D. The cognition and emotional well-being indices of the Parkinson’s disease questionnaire-39: what do they really measure? Parkinsonism Relat Disord. 2014; 20(11):1236–41. Epub 2014/09/28. https://doi.org/10.1016/j.parkreldis.2014.09.014 PMID: 25260967; PubMed Central PMCID: PMC4321103.

21. Hagell P, Nilsson MH. The 39-item Parkinson’s Disease Questionnaire (PDQ-39): Is it a Unidimensional Construct? Therapeutic advances in neurological disorders. 2009; 2(4):205–14. Epub 2009/07/01. https://doi.org/10.1177/1756285609103728 PMID: 21179529; PubMed Central PMCID: PMC3002633.

22. Lawson RA, Yarnall AJ, Duncan GW, Khoo TK, Breen DP, Barker RA, et al. Severity of mild cognitive impairment in early Parkinson’s disease contributes to poorer quality of life. Parkinsonism Relat Disord. 2014; 20(10):1071–5. Epub 2014/07/31. https://doi.org/10.1016/j.parkreldis.2014.07.004 PMID: 25074728; PubMed Central PMCID: PMC4194347.

23. Leroi I, McDonald K, Pantula H, Harbishettar V. Cognitive impairment in Parkinson disease: impact on quality of life, disability, and caregiver burden. Journal of geriatric psychiatry and neurology. 2012; 25(4):208–14. Epub 2012/11/23. https://doi.org/10.1177/0891988712464823 PMID: 23172765.

24. Cui SS, Du JJ, Fu R, Lin YQ, Huang P, He YC, et al. Prevalence and risk factors for depression and anxiety in Chinese patients with Parkinson disease. BMC geriatrics. 2017; 17(1):270. Epub 20171122. https://doi.org/10.1186/s12877-017-0666-2 PMID: 29166864; PubMed Central PMCID: PMC5700465.