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SHORT REPORT

Driving in Parkinson's disease: a retrospective study of driving and mobility assessments

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Abstract

Background: To guide decision-making about driving ability, some patients with Parkinson's disease (PD) undergo specialist driving assessment. However, decisions about driving safety in most patients need to be made without this definitive test. There is no consensus on what predicts unsafe driving in PD nor a validated prediction tool to guide clinician decision-making and the need to refer for further assessment.
Objectives: To describe the characteristics of patients with PD assessed at a Driving Mobility Centre and investigate factors that predict driving assessment outcome.
Methods: Retrospective cohort study of patients with PD assessed between 2012 and 2016. Descriptive analyses and logistic models to determine factors predicting a negative outcome.
Results: There were 86 assessments of patients with PD. The mean age was 70 years (±9.2), 86% were male, median disease duration 7 years (interquartile range 5–12.5 years) and 59% were referred by the Driver and Vehicle Licensing Agency. In total, 62% had a negative 'not drive' outcome. The Rookwood Driving Battery (RDB), depth of vision deficit, usual driving frequency, age, duration license held and response time were all predictors in univariable analysis. The RDB was the best predictor of assessment failure, conditional on other variables in a backward stepwise model (odds ratio 1.29; 95% confidence interval 1.05, 1.60; $P = 0.015$).
Conclusions: This is the first study to describe patients with PD undergoing driving assessments in the UK. In this population, RDB performance was the best predictor of outcome. Future prospective studies are required to better determine predictors of driving ability to guide development of prediction tools for implementation into clinical practice.

Keywords: *Parkinson's*, *driving*, *cognition*, *Rookwood Driving Battery*, *older people*

Key Points

- There is a lack of evidence as to what predicts driving ability in Parkinson's disease.
- Rookwood Driving Battery score was predictive of a negative driving assessment outcome in this retrospective study.
- Increasing age, license tenure, response time, depth of vision deficit and shorter driving distance were also predictive.
- Further prospective studies are required to better understand what governs driving ability in PD.

Introduction

Parkinson's disease (PD) is a common and complex neurodegenerative disorder causing physical, cognitive and visual impairments. These impairments include bradykinesia, rigidity, tremor, freezing, poor attention and impaired visuo-spatial awareness. Such impairments affect driving

performance on standardised road tests [1–3], driving simulator experiments [3–6] and lead to increased crashes [7, 8]. High rates of driving cessation in PD [7, 9, 10] lead to greater inactivity, social isolation, depression and caregiver burden [11, 12].

Accurate assessment of driving ability in PD is needed to ensure road safety and prevent premature driving cessation. In the UK, some patients undergo specialist driving assessments at 20 Driving Mobility Centres [13, 14] following self-referral or referral from clinicians and various agencies including the Driver and Vehicle Licensing Agency (DVLA). Driving assessments involve off- and on-road components. The gold-standard on-road driving assessment is time and resource intensive so not available to all patients. Off-road assessments, such as the Rookwood Driving Battery (RDB), have therefore been developed to predict on-road driving ability, through testing cognitive domains required for safe driving [15, 16]. At present, the driving assessment outcome remains a global impression of the patient's ability in both off- and on-road components [17].

Although the final decision about license status lies with the DVLA, clinicians caring for patients with PD are faced with practically managing decisions about driving ability. Clinician experience alone cannot predict driving ability [2], yet only a minority of patients are undergoing definitive assessments. There is currently no validated prediction tool to guide clinicians about the thresholds in impairments which make driving unsafe or when to refer for driving assessment. The characteristics of those patients who are referred for assessment are also unknown.

Developing a clinical prediction tool requires understanding of which disease features predict driving impairment. To date, studies examining predictors of driving ability in PD have used small sample sizes, varying neuropsychological tests and disease rating scales and have lacked controls, resulting in a weak evidence base and no consensus [18].

The aims of this study were to (i) describe the characteristics of patients with PD assessed at a Driving Mobility Centre and (ii) investigate which factors were predictors of driving assessment outcome.

Methods

Study design

This is a retrospective cohort study of patients with idiopathic PD assessed at the Driving and Mobility Centre (West of England), The Vassall Centre, Bristol, UK. This Centre serves a population of 1,696,604 people.

Data collection

A systematic search of all records at the Driving Centre was undertaken and identified 2,082 assessments conducted between 1 October, 2012 and 31 December 2016. Following screening of the referral letter for a diagnosis of idiopathic PD, 1976 of these assessments were excluded. Five withdrew before assessment was undertaken. Fifteen secondary assessments of the same patient were also excluded. Data from 86 patients were available for analysis (see Figure 1).

Data for each patient were extracted from paper records held at the driving centre (please see Figure 1 and Appendix 1 in the Supplementary data on the journal website (www.academic.oup.com/ageing)). Cognition was determined from either Montreal Cognitive Assessment [19] or RDB [16]. Each of the 12 subtests of the RDB are given a score of 0 (pass), 1 (borderline) and 2 (fail). These scores are totalled to give the overall battery score ranging from 0 to 22, with a higher score representing a worse performance [16]. The outcome of the driving assessment was recorded as 'drive' or 'not drive'.

All participants consented at the time of assessment for their data to be used for research purposes. Ethical approval was granted by the University of Bristol Ethics Committee on 15 January 2017 and institutional approval from the Driving Mobility Board on 17 February 2017.

Statistical methods

Variables were described using the mean (standard deviation (SD)) if normally distributed and median (interquartile range (IQR)) if skewed. Categorical variables were described as frequency and percentage. Associations between characteristics and driving assessment outcome were assessed using univariable logistic regression. From this, candidate predictors, with a P-value of <0.05, were included in a backward stepwise multivariable logistic regression model [20]. Starting with all candidate variables, this model iterates so that at each step the variable with the largest P-value ≥ 0.05 is removed, continuing until no variables with P-values ≥ 0.05 remain. All analyses were performed using Stata version 15.0 [21].

Results

Patient, disease and driving characteristics

The patient's disease and driving characteristics are summarised in Table 1. The mean age was 70 years old (±9.2) and the majority of subjects were male (86%). Most had been referred for assessment by the DVLA (59%), held a full license (47%) and drove a manual transmission vehicle (55%). Most participants were only driving in the local area (47%) and had been driving in the last 6 days (69%). Equal proportions were driving less than (24%) and more than (34%) weekly.

The median disease duration was 7 years (IQR 5–12.5). The RDB was the predominant cognitive test used (67%). The average RDB score was 6 (IQR 2–9). The majority of subjects did not demonstrate a depth of vision (53%) nor visual field deficit (66%). The median lowest contrast sensitivity seen was 20% (IQR 10–20) and 71% of subjects passed the glare recovery test. Median response time was 0.60 seconds (IQR 0.51–0.68). The assessment outcome was

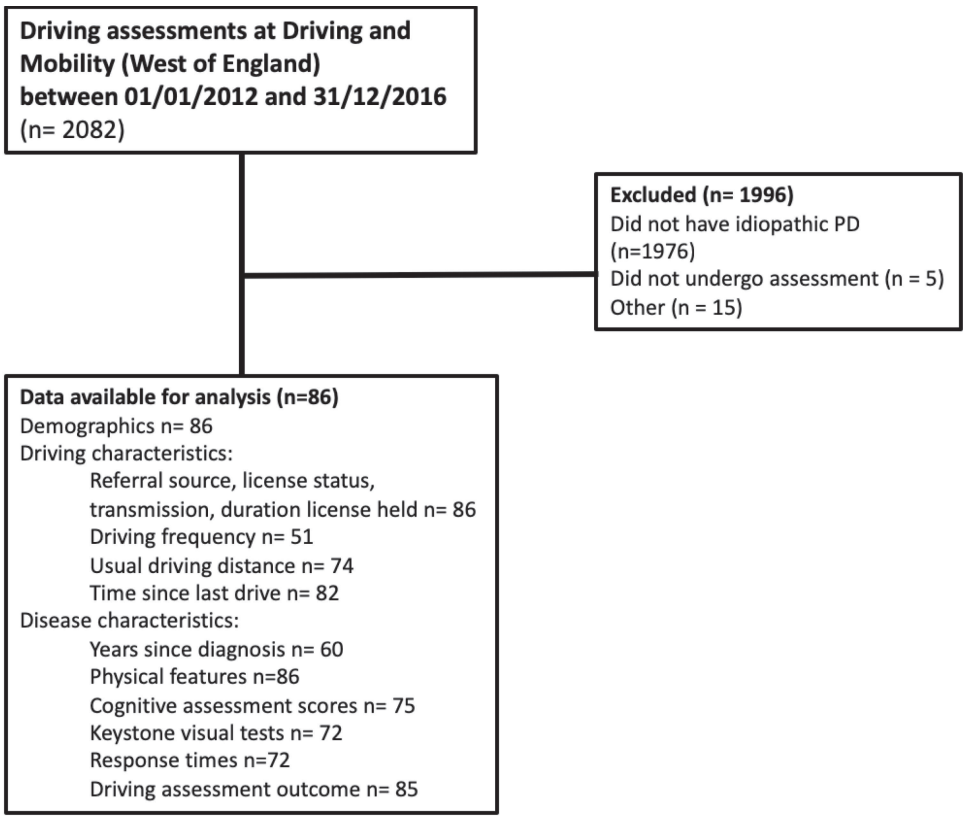

Figure 1. Exclusion and inclusion of patients during the study period and summary of data collected. PD = Parkinson's disease.

mostly negative with 63% of participants given a 'not drive' outcome.

Relationship between characteristics and driving assessment outcome

Age, duration license held, overall RDB score, usual driving distance, depth of vision deficit and response time were found to be significantly different between assessment outcome groups. On inclusion of these candidate variables in a backwards stepwise logistic regression, the RDB overall score was found to be the best predictor of driving assessment failure, conditional on the other variables (odds ratio, 1.29; 95% confidence interval, 1.05, 1.60; $P = 0.015$).

Discussion

Our results show that patients with PD undergoing driving assessment are mostly men, with a mean age of 70 and disease duration of 7 years. They are experienced drivers who drive regularly but locally. Most assessments result in people no longer being able to drive. The RDB is the most commonly used cognitive battery and RDB performance was the best predictor of driving assessment outcome in our population. With each point increase in the RDB score, the likelihood of no longer driving increased by 45%. Increasing age, presence of a depth of vision deficit, shorter usual driving distance and increased response times were also found to predict test failure.

To the best of our knowledge, this is the first study to provide real-world data on patients with PD collected during specialist driving assessments. The demographic characteristics we describe are similar to those of community-dwelling patients with PD [22] and to a previous meta-analysis of studies examining driving in PD [23]. However, the large proportion of negative assessment outcomes seen in our study differs from previous experimental studies, which found that the majority of subjects were safe to continue driving [18, 24]. This difference is likely to represent a selection bias for more impaired patients referred for assessment at Driving Mobility centres than those recruited as study participants. Understanding what prompted their referral and at what threshold could guide future work developing a clinical driving prediction tool.

Our finding that cognitive impairment is the biggest predictor of poor driving ability is supported by the existing literature [18, 24, 25]. Cognitive testing should hence form a key component of a predictive tool of driving ability in PD. However, significant impairment in other symptom domains, e.g. motor function, could deem driving unsafe despite good cognitive ability. For this reason, a predictive tool to guide clinicians should include screening within all domains predictive of driving ability. Due to differences in sample sizes, rating scales of predictors, outcome measures of

Table 1. Patient, disease, driving characteristics and univariable logistic regression (summary version—please see Appendix 2 in the Supplementary data on the journal website for full version (www.academic.oup.com/ageing)). Data are n (%), mean (SD), median (IQR). OR = odds ratio, CI = 95% confidence interval, P = *P*-value, DVLA = Driver and Vehicle Licensing Agency, GP = General practitioner, Section 88 = Section 88 of Road Traffic Act 1988, PD = Parkinson's disease, RDB = Rookwood Driving Battery.

Predictor variable	Total, *n* = 86	Drive, *n* = 29	Not drive, *n* = 54	OR (95% CI)	*P*-value
Demographics					
Age	70 ± 9.2	66.4 ± 7.1	71.9 ± 9.7	1.07 (1.01, 1.13)	**0.013**
Gender					
Female	12 (14)	5 (17)	7 (13)	1	
Male	74 (86)	24 (83)	47 (87)	1.40 (0.40, 4.88)	0.598
Driving Characteristics					
Referral source					
Self	17 (20)	6 (21)	11 (20)	1	1
DVLA	51 (59)	16 (55)	32 (59)	1.09 (0.34, 3.49)	0.883
Other (GP, mobility, secondary health care professional)	18 (21)	7 (24)	11 (20)	0.86 (0.22, 3.39)	0.826
License status					
Full	40 (47)	15 (52)	25 (46)	1	
Section 88	34 (40)	11 (38)	20 (37)	1.09 (0.41, 2.89)	0.861
None	12 (14)	3 (10)	9 (17)	1.80 (0.42, 7.71)	0.428
Transmission					
Automatic	39 (45)	13 (45)	25 (46)	25 (46)	
Manual	47 (55)	16 (55)	29 (54)	0.94 (0.38, 2.33)	0.898
Duration license held	49.2 ± 10.2	46 ± 8.8	50.7 ± 10.6	1.05 (1.00, 1.10)	**0.048**
Driving frequency					
More than weekly	29 (34)	12 (41)	15 (28)	1	
Less than weekly	21 (24)	6 (21)	14 (26)	1.87 (0.55, 6.33)	0.316
Time since last drive					
1–6 days	59 (69)	23 (79)	33 (61)	1	
≥7 days	23 (27)	5 (17)	18 (33)	2.51 (0.81, 7.73)	0.109
Usual driving distance					
National/International	18 (21)	11 (38)	6 (11)	1	
Regional	16 (19)	3 (10)	12 (22)	7.33 (1.47, 36.7)	**0.015**
Local	40 (47)	11 (38)	28 (52)	4.67 (1.38, 15.7)	**0.013**
Disease characteristics					
Number of years since diagnosis	7 (5–12.5)	7 (5–12)	7 (5–13)	0.99 (0.90, 1.09)	0.884
RDB Overall Score[a]	6 (2–9)	2.5 (1–4.5)	8 (5–12)	1.45 (1.17, 1.80)	**0.001**
Depth of Vision Deficit					
No	46 (53)	22 (76)	24 (44)	1	
Yes	35 (41)	5 (17)	27 (50)	4.95 (l.62, 15.1)	**0.005**
Presence of visual field deficit					
No	57 (66)	22 (76)	34 (63)	1	
Yes	24 (28)	6 (21)	16 (29)	1.73 (0.59, 5.08)	0.322
Contrast sensitivity (lowest %)	20 (10–20)	20 (10–20)	20 (10–30)	1.03 (0.99, 1.08)	0.140
Glare recovery					
Pass	61 (71)	23 (79)	36 (67)	1	
Fail	11 (13)	0 (0)	11 (20)		
Mean response time (10 ms)	60 (51–68)	54 (50–63)	60 (52–72)	1.06 (1.01, 1.11)	**0.030**

Bold highlights *P* -value of <0.05, indicating candidate predictors for inclusion in the multivariable model.
[a]Lower score indicates better performance.

driving ability and heterogeneous samples within the existing literature, there remains a weak evidence base of predictors to guide development of such a tool [18].

This study is strengthened by its novelty, pragmatism and high number of records (>2,000) screened over a 5-year period. However, there are several important limitations. Data obtained during driving assessments is non-standardised, and so retrospective collection led to a degree of missing data. We based the diagnosis of PD on referral criteria, and therefore patients with parkinsonism of other aetiologies may have been included. Our assessment of the value of the RDB in predicting a negative assessment outcome is likely to be biased, resulting in an over-estimation of its worth. This has arisen because this battery is part of the global impression used to decide assessment outcome. As a result, there is an element of circularity to assessing its predictive value, as the gold standard is not independent of the screening test.

Future studies in a larger unselected population with prospective systematic data collection are now needed to better understand which disease characteristics predict driving ability in PD and the thresholds which render driving unsafe.

This knowledge can guide the development of a clinical prediction tool to inform clinicians about driving prognosis, referral thresholds and assessment frequency.

Supplementary data Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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Conflict of Interest D.G. discloses personal consulting fees from Novartis Pharma AG. V.H. has received speaker fees from Profile Pharma. R.S. has received research funding from Par kinson's UK and the Health Foundation. He has received honoraria from UCB Pharma. H.M. is employee of Driving and Mobility (West of England). Y.B.S. has received research funding from Parkinson's UK, National Institute of Health Research (NIHR), the Gatsby Foundation and Medical Research Council. E.H. has received research funding from Parkinson's UK, NIHR Health Technology Assessment, the Gatsby Foundation and the British Geriatrics Society. She has received travel, consultancy and honoraria from Profile, Bial, AbbVie, Luye and EVER Pharma.

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