RESEARCH ARTICLE

Parkinson's Disease Motor Subtypes and Mood

David J. Burn, MD, FRCP,[1] Sabine Landau, PhD,[2] John V. Hindle, FRCP,[3,4] Michael Samuel, MD,[5,6] Kenneth C. Wilson, MD,[7] Catherine S. Hurt, PhD,[8] and Richard G. Brown, PhD[8,9]*, for the PROMS-PD Study Group

[1]*Institute for Ageing and Health, Newcastle University, Newcastle upon Tyne, UK*
[2]*Department of Biostatistics, Institute of Psychiatry, King's College London, London, UK*
[3]*Department of Care of the Elderly, Llandudno Hospital, Llandudno, UK*
[4]*School of Medical Sciences, University of Bangor, Bangor, UK*
[5]*Department of Neurology, King's College Hospital NHS Foundation Trust, King's Health Partners, London, UK*
[6]*Department of Neurology, East Kent Hospital NHS Foundation Trust, Ashford, Kent, UK*
[7]*EMI Academic Unit, St Catherine's Hospital, University of Liverpool, Wirral, UK*
[8]*Department of Psychology, Institute of Psychiatry, King's College London, London, UK*
[9]*MRC Centre for Neurodegeneration Research, King's College London, London, UK*

ABSTRACT: Parkinson's disease is heterogeneous, both in terms of motor symptoms and mood. Identifying associations between phenotypic variants of motor and mood subtypes may provide clues to understand mechanisms underlying mood disorder and symptoms in Parkinson's disease. A total of 513 patients were assessed using the Hospital Anxiety and Depression Scale, and separately classified into anxious, depressed, and anxious-depressed mood classes based on latent class analysis of a semistructured interview. Motor subtypes assessed related to age-of-onset, rate of progression, presence of motor fluctuations, lateralization of motor symptoms, tremor dominance, and the presence of postural instability and gait symptoms and falls. The directions of observed associations tended to support previous findings with the exception of lateralization of symptoms, for which there were no consistent or significant results. Regression models examining a range of motor subtypes together indicated increased risk of anxiety in patients with younger age-of-onset and motor fluctuations. In contrast, depression was most strongly related to axial motor symptoms. Different risk factors were observed for depressed patients with and without anxiety, suggesting heterogeneity within Parkinson's disease depression. Such association data may suggest possible underlying common risk factors for motor subtype and mood. Combined with convergent evidence from other sources, possible mechanisms may include cholinergic system damage and white matter changes contributing to non-anxious depression in Parkinson's disease, while situational factors related to threat and unpredictability may contribute to the exacerbation and maintenance of anxiety in susceptible individuals.

Key Words: anxiety; depression; fluctuations; phenotype; PIGD

***Correspondence to:** Richard G. Brown, Institute of Psychiatry (PO77), De Crespigny Park, London, SE5 8AF, UK; richard.g.brown@kcl.ac.uk

Funding agencies: The work reported here was supported by Parkinson's UK (grant number J-0601). Research support was also received from the UK Department of Health via the National Institute for Health Research (NIHR) Specialist Biomedical Research Centre for Mental Health award to South London and Maudsley NHS Foundation Trust (SLaM) and the Institute of Psychiatry at King's College London; the NIHR Dementias and Neurodegenerative Diseases Research Network (DeNDRoN), and the Wales Dementias and Neurodegenerative Diseases Research Network (NEURODEM Cymru).

Relevant conflicts of interest/financial disclosures: Nothing to report. Full financial disclosures and author roles may be found in the online version of this article.
Members of the PROMS-PD Study Group who contributed to this work are listed in the Appendix.

Received: 15 June 2011; **Revised:** 2 September 2011; **Accepted:** 24 October 2011
Published online 11 December 2011 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/mds.24041

Depression and anxiety are common and clinically important features of Parkinson's Disease (PD). They can precede the onset of the motor symptoms[1,2] suggesting that Lewy-related and other pathology in selectively vulnerable structures may contribute to both motor and non-motor features.[3] Pathological data has suggested greater neuronal loss and gliosis in catecholaminergic areas of the brain (specifically, the locus coeruleus, dorsal vagus nerve, and substantia nigra, pars compacta) in depressed patients,[4] while in vivo imaging studies suggest possible associations with both serotonergic and noradrenergic systems[5] and white-matter abnormalities.[6] The presence and severity of depression and anxiety has no linear relation with disease duration and is either unrelated (or only

modestly associated) with the severity of the motor symptoms,[7] observed in patients with early, mild disease as well as those with more advanced symptoms.[8] This implies that any association between depression, anxiety, and motor symptoms does not directly reflect common nigrostriatal pathology and frontostriatal pathophysiology.

PD is a complex and variable disease with distinct clinical phenotypic subtypes involving both motor and non-motor features.[9] Depression has been linked to the akinetic-rigid form of PD compared to patients with a tremor dominant profile,[10–13] and in patients with postural instability and gait disturbance (PIGD), particularly falls, versus those with a non-PIGD profile.[13–16] Depression has also been associated with more rapid progression,[10,17,18] and with motor complications of therapy,[15,19] although not in all studies.[11,14,20] There is also some evidence that patients with a younger age at disease onset show increased risk of depression,[17,19,21] although other studies have found either no such association or have even shown increased risk with later onset.[10,11,14,15,22] Finally, an association between depression and right-sided motor asymmetry has been suggested[21,23,24] but not confirmed in all studies.[25,26]

For anxiety, associations with the akinetic-rigid or PIGD motor phenotype are few and inconsistent,[12,15,27] while there is no evidence regarding rate of disease progression and only a single negative report relating to lateralization of motor symptoms.[28] The strongest evidence emerging is an association between anxiety and young age-of-onset[15,20,28–30] and the presence of motor complications of treatment.[15,28–31]

The present study assessed, in a large sample of patients, a range of clinical and motor features suggested by previous research to be associated with depression and/or anxiety. Using a regression approach we aimed to determine the relative (rather than individual) significance of these often interdependent factors, providing better clues to guide research and improve management

Patients and Methods

Patients with a diagnosis of PD were recruited from specialist movement disorder and care of the elderly clinics as described elsewhere.[32] Self-reported depressive and anxiety symptoms were assessed using the Hospital Anxiety and Depression Scale (HADS).[33] A subscale score of $\geq$11 on the HADS was taken to indicate significant depressive or anxiety symptoms. Phenomenological data relating to depression and anxiety were collected by trained staff using a semistructured interview, the Geriatric Mental State, designed and validated for use in older adults including patients with dementia.[34] Based on a latent class analysis (LCA) of these data, patients were categorized into 4 classes: "Anxious-Depressed" (8.6%), "Depressed" (9.0%), and "Anxious" (22%), while a fourth group (60.4%) comprised patients with low levels of psychiatric symptomatology.[32] Activities of daily living and motor function were assessed using the Unified Parkinson's Disease Rating Scale (UPDRS) parts II and III[35] and disease stage with the Hoehn and Yahr Scale.[36] Cognitive function was assessed using the Addenbrooke's Cognitive Examination-Revised (ACE-R),[37] which incorporates the Mini-Mental State Examination (MMSE).[38] Levodopa equivalent daily dose (LEDD) was calculated as described elsewhere.[39]

Classification of Parkinson subtypes was based on previously reported studies. Younger age-of-onset was defined as onset of motor symptoms before the age of 55 years. Motor subtype was identified as PIGD or tremor dominant/indeterminate[40] and as tremor dominant or non-tremor dominant (akinetic-rigid).[10] Patients were also classified according to whether they reported postural instability and falls (PIF) (UPDRS Part II item 13 $>$1) and freezing of gait (FOG) (UPDRS Part II item 14 $>$1).[16] Rate of disease progression was estimated from cross-sectional data by dividing the UPDRS-III total by duration of disease since diagnosis in years[10] and dichotomized on the sample median. Motor complications of treatment (present or absent) were defined as motor fluctuations and/or sudden onset fluctuations (UPDRS Part IV). Lateralization was determined from the left and right side motor symptom scores on the UPDRS Part III. The study was approved by the South East Research Ethics Committee (ref. 07/MREC01/9). All participants gave written informed consent.

Statistical Analysis

The clinical characteristics of the dichotomized subtypes were compared using parametric or nonparametric analysis of variance (ANOVA). These comparisons were not hypothesis or model testing and no correction was made for multiple comparisons. The values of *P* provide an indication of the strength of evidence supporting differences between subtypes comparable to previous reports. Continuous measures of anxiety and depression were compared between the dichotomized Parkinson subtypes using parametric ANOVA, again for descriptive purposes, with age as a covariate when this was found to differ between subtypes. Three types of categorical data were compared (Fisher's exact or tests of linear-by-linear association) with adjustment made for multiple comparisons (critical $P = .017$). Logistic regression (forced entry method) was used to indentify predictors of categorical depression, anxiety (binary regression), and mood class (multinomial regression). Analyses were performed using PASW Statistics, version 18 (Chicago, IL).

TABLE 1. Demographic and clinical characteristics (N = 513)

Variable	Mean (SD)/ median[a]/%	Range
Demographic and social		
Age (y)	67.9 (10.3)	32–94
Gender (% male)	65.1%	–
PD history, symptoms, and treatment		
Age at PD onset (y)	61.0 (12.1)	13–92
Duration on PD (y)	5.0[a]	0–39
UPDRS-III (total score)	26.4 (12.0)	4–78
LEDD (mg/day)	600[a]	0–7565
Hoehn and Yahr stages I/II–III/IV–V (%)	12.6/80.2/7.2%	–
Rate of progression (median)	5.25	1–31
Cognitive function		
ACE-R (total score)	86.4 (10.7)	30–100
ACE-R $\leq$ 83 (%)	29.7%	–
MMSE (total score)	27.9 (2.5)	16–30
Depression and Anxiety		
HADS-Depression	6.3 (3.7)	0–17
HADS-Depression $\geq$11 (%)	13.0%	–
HADS-Anxiety	7.2 (4.5)	0–20
HADS-Anxiety $\geq$11 (%)	22.0%	–
HADS-Total score	13.5 (7.2)	0–37

[a]Median value.
SD, standard deviation; PD, Parkinson's disease; UPDRS, Unified Parkinson's Disease Rating Scale; LEDD, L-dopa equivalent daily dose; ACE-R, Addenbrooke's Cognitive Examination–Revised; MMSE, Mini-Mental Status Examination; HADS, Hospital Anxiety and Depression Scale.

Results

Sample details (N = 513) are provided in Table 1. Table 2 shows the demographic and clinical characteristics according to Parkinson subtype, while Table 3 shows the relationship between motor subtypes and mood. There was no significant relationship between lateralization of motor symptoms, depression and anxiety (in all instances $P > .10$) and these results are not considered further. Patients with onset at less than 55 years had higher mean HADS anxiety score and a higher proportion showed significant anxiety. The proportion of patients in the 3 mood classes also differed significantly with higher proportions of early-onset patients in the 2 anxiety-related classes (Classes 1 and 3), while the older-onset group was more frequent in the "depressed" class (Class 2). Patients with either PIGD or non-tremor dominant subtypes were somewhat more depressed on the HADS. The PIGD or non-tremor dominant subtypes were more strongly represented in all 3 of the empirical mood classes compared to the non-PIGD or tremor dominant patients. Patients with either FOG or PIF were more depressed and anxious as assessed by the HADS. Those with FOG also showed increased levels of significant depression and anxiety, with the rate of depression almost 4 times that of patients without FOG. Patients with motor fluctuations were more depressed and anxious on the HADS, with increased rates of significant

TABLE 2. Parkinson subtypes: demographic and clinical characteristics

Subtype	n	Age (y), mean (SD)	Gender (% male)	Age of onset of PD (y), mean (SD)	PD duration (y), median (min-max)	UPDRS (III) total, mean (SD)	LEDD (mg/day), median (min–max)	ACE-R total, mean (SD)
Age of onset (y)								
<55	157	57.7 (8.3)[a]	63.7	46.7 (6.6)[a]	10.0 (0–39)[a]	26.4 (13.2)	800 (0–3641)[a]	89.0 (10.2)[a]
≥55	356	72.4 (7.6)	65.7	67.3 (7.9)	4.0 (0–23)	26.6 (11.4)	500 (0–7565)	85.3 (10.7)
Motor phenotype (a)								
PIGD	369	68.6 (9.9)[c]	63.4	61.0 (12.1)	6.0 (0–39)[a]	27.9 (11.5)[a]	640 (0–7565)[a]	85.5 (11.1)[b]
Non-PIGD	144	66.1 (11.3)	69.4	61.0 (12.1)	3.5 (0–28)	23.2 (12.6)	430 (0–3169)	88.7 (8.9)
Motor phenotype (b)								
Non-tremor	420	68.2 (9.9)	63.6	60.1 (12.2)	5.0 (0–39)[a]	27.7 (11.5)[a]	620 (0–7565)[a]	85.9 (10.9)[c]
Tremor	93	66.5 (12.0)	72.0	61.3 (11.9)	3.0 (0–27)	21.4 (12.7)	420 (0–2960)	88.7 (9.3)
Freezing of gait								
Yes	75	67.3 (10.1)	72.0	56.1 (13.1)[a]	10.0 (0–39)[a]	35.5 (13.0)[a]	800 (0–7565)[a]	83.2 (11.6)[b]
No	438	68.0 (10.4)	63.9	61.8 (11.7)	4.0 (0–28)	25.0 (11.1)	575 (0–3641)	86.9 (10.4)
Postural instability/falls								
Yes	77	68.5 (9.7)	64.9	55.7 (13.9)[a]	13.0 (0–39)[a]	34.1 (11.8)[a]	920 (210–2800)[a]	81.4 (12.0)[a]
No	436	67.7 (10.5)	65.1	61.9 (11.5)	4.0 (0–28)	25.2 (11.5)	531 (0–7565)	87.3 (10.2)
Motor fluctuation								
Yes	138	64.4 (9.8)[a]	59.4	54.3 (10.5)[a]	10.0 (0–26)[a]	29.2 (12.9)[b]	922 (100–7565)[a]	87.2 (10.7)
No	375	69.1 (10.2)	67.2	63.4) (11.7)	4.0 (0–39)	25.6 (11.5)	495 (0–3641)	86.1 (10.6)
Rate of progression								
"Fast"	259	68.7 (11.1)	68.0	65.3 (11.5)[a]	3.0 (0–13)[a]	29.1 (11.0)[a]	481 (377)[a]	85.8 (10.5)
"Slow"	254	67.0 (9.4)	62.1	56.6 (11.1)	10.0 (1–39)	24.0 (12.4)	924 (694)	87.1 (10.7)

[a]$P < .001$.
[b]$P < .01$.
[c]$P < .05$.
SD, standard deviation; PD, Parkinson's disease; UPDRS, Unified Parkinson's Disease Rating Scale; LEDD, L-dopa equivalent daily dose; ACE-R, Addenbrooke's Cognitive Examination–Revised; PIGD, postural instability and gait disturbance.

TABLE 3. Parkinson subtypes: relationship to depression, anxiety, and mood class

	HADS depression total[a]	HADS depression ≥11 (%)[b]	HADS anxiety total[a]	HADS anxiety ≥11 (%)[b]	Class 1 (%) "anxious-depressed"	Class 2 (%) "depressed"	Class 3 (%) "anxious"	Mood class significance[c]
Age of onset (y)								
<55	6.6 (3.9)	17.3	8.7 (4.7)***	31.4*	17.8	6.4	32.5	**
≥55	6.1 (3.5)	11.0	6.5 (4.2)	17.6	4.5	10.1	17.4	
Motor phenotype-a								
PIGD	6.6 (3.6)*	14.6	7.5 (4.3)	23.1	9.2	11.4	24.4	*
Non-PIGD	5.3 (3.6)	9.2	6.5 (4.7)	19.1	6.9	2.8	16.0	
Motor phenotype-b								
Non-tremor	6.6 (3.6)*	14.2	7.4 (4.3)	22.9	9.3	10.0	24.3	*
Tremor	5.0 (3.6)	7.8	6.2 (4.9)	17.8	5.4	4.3	11.8	
Freezing of gait								
Yes	8.9 (4.5)**	34.7**	8.8 (4.6)**	33.3*	21.3	17.3	16.0	**
No	5.8 (3.3)	9.3	6.9 (4.4)	20.0	6.4	7.5	23.1	
Postural instability/falls								
Yes	7.8 (3.8)**	19.2	9.1 (4.7)**	31.5	22.1	14.3	24.7	**
No	6.0 (3.6)	12.0	6.9 (4.3)	20.3	6.2	8.0	21.6	
Motor fluctuations								
Yes	7.3 (3.7)**	20.0*	8.5 (4.3)*	30.4*	15.9	10.9	33.3	**
No	5.9 (3.6)	10.4	6.7 (4.4)	18.8	5.9	8.3	17.9	
Rate of progression								
''Fast''	6.6 (3.6)**	14.5	7.4 (4.6)**	25.2	8.1	9.7	18.5	
''Slow''	6.0 (3.7)	11.3	7.0 (4.3)	18.5	9.1	8.3	25.7	

[a]For HADS depression and anxiety totals: *$P < .05$, **$P < .01$, ***$P < .001$.
[b]For HADS depression and anxiety ≥11; *$P < .017$, **$P < .003$.
[c]For test of proportion of classes 1–3 across the 2 subtypes, linear-by-linear association: *$P < .017$, **$P < .003$.
HADS, Hospital Anxiety and Depression Scale; PIGD, postural instability and gait disturbance.

depression and anxiety, and were more strongly represented in all 3 affective classes but particularly in the anxiety-related ones. Finally, patients with faster rate of progression were slightly more depressed and anxious than those with slower rates of progression, but did not differ in mood class distribution.

Logistic regression was used to assess which Parkinson subtype(s) best predicted the presence of depression (HADS depression ≥11), anxiety (HADS anxiety ≥11) (N = 490), or mood class (N = 512) (Table 4). The PIGD/non-PIGD and non-Tremor/Tremor classifications produced similar results and only the former is reported in the final model (Table 4). The full set of dichotomized predictors was: age-of-onset (''early'' <55 years, ''late'' ≥55 years), motor subtype (PIGD, non-PIGD), PIF subtype (present, absent), FOG subtype (present, absent), motor fluctuations (present, absent), and rate of progression (''fast,'' ''slow''), with the second

TABLE 4. Predictors of significant depression and anxiety (HADS) and mood class (class 4 reference): results of logistic regression

	HADS-Depression ≥11	HADS-Anxiety ≥11	Overall mood class	Mood class contrasts		
Overall Model fit	χ^2 (6) = 37.20[a]	χ^2 (6) = 29.30[a]	χ^2 (6) = 109.2[a]	"anxious-depressed" versus "healthy"	"depressed" versus "healthy"	"anxious" versus "healthy"
Predictor	HADS-Depression ≥11 [OR (95% CI)]	HADS-Anxiety ≥11 [OR (95% CI)]	Likelihood ratio test	[OR (95% CI)]	[OR (95% CI)]	[OR (95% CI)]
Young onset	1.58 (0.84–2.96)	2.33 (1.46–3.85)[a]	[a]	5.37 (2.50–11.52)[a]	0.88 (0.38–2.03)	2.52 (1.52–4.12)[a]
PIGD subtype	1.49 (0.73–3.02)	1.18 (0.69–1.99)	[a]	1.19 (0.52–2.74)	4.51 (1.55–13.16)[b]	1.94 (1.13–3.36)[b]
PIF subtype	0.72 (0.33–1.61)	1.27 (0.68–2.40)		2.95 (1.24–6.99)[b]	1.63 (0.69–3.83)	1.30 (0.65–2.62)
FOG subtype	5.00 (2.56–9.71)[a]	1.54 (0.83–2.85)	[b]	2.07 (0.89–4.83)	2.09 (0.94–4.67)	0.57 (0.26–1.24)
Motor fluctuations	2.10 (1.17–3.79)[b]	1.58 (0.95–2.61)	[a]	2.49 (1.18–5.24)[b]	1.79 (0.85–3.76)	2.54 (1.52–4.24)[a]
Fast progression	1.77 (0.99–3.17)	2.25 (1.38–3.67)[a]		1.90 (0.90–4.00)	1.24 (0.63–2.44)	1.00 (0.62–1.62)

Significance of "Mood class" indicates the contribution of the predictor in overall multinomial model; significance for individual classes 1–3 indicates the contribution of the predictor to the contrast between that class and the reference "Healthy" class.
[a]$P < .003$.
[b]$P < .017$.
HADS, Hospital Anxiety and Depression Scale; OR, odds ratio; 95% CI, 95% confidence interval; PIGD, postural instability and gait disturbance; PIF, postural instability and falls; FOG, freezing of gait.

category as the reference in each case. All potential predictors were entered into the models. Most associations were positive (predictor associated with worst mood), in agreement with previous findings. Significant predictors of HADS depression were FOG subtype and the presence of motor fluctuations. HADS anxiety was predicted by younger age-of-onset and rapid disease progression. The 3 mood classes were analyzed in a multinomial model with Class 4 (no prominent symptoms) as the reference category. Young onset, PIGD and FOG subtypes, and motor fluctuations were significant in the overall model. Membership of the anxious-depressed class (Class 1) was specifically predicted by young onset, PIF subtype, and motor fluctuations. Anxiety (without depression) (Class 3) was predicted by young onset, PIGD, and motor fluctuations. Finally, depression (without anxiety) (Class 2) was predicted only by PIDG subtype.

Because of the associations between some of the predictors and cognitive status (Table 2), secondary analyses were carried out to assess whether cognitive impairment (ACE-R <83) added to the 3 models described above. Impairment was a significant independent predictor of HADS depression (odds ratio [OR] = 1.99; 95% confidence interval [CI], 1.08–3.69; $P = .027$) but not HADS anxiety (OR = 0.73; 95% CI, 0.42–1.28; $P = .282$). Similarly, cognitive impairment predicted membership of the Depression class (OR = 3.06; 95% CI, 1.05–8.92; $P = .041$) but not the Anxious-Depressed (OR = 1.63; 95% CI, 0.59–4.45; $P = .35$) or Anxious classes (OR = 0.63; 95% CI, 0.26–1.51; $P = .295$).

Discussion

This study confirms the significance of some, but not all, of the features of PD shown previously to be associated with depression and expands our knowledge in relation to anxiety. The univariate results lend some support for an association between younger age-of-onset and depression, but much more strongly for anxiety. In the regression analyses, even with other predictors in the model, age-of-onset below 55 years (mean, 46.7) was strongly associated with the presence of clinically significant anxiety and membership of both anxiety-related classes. The profile of anxiety in these classes[32] is similar to that seen in generalized anxiety disorder (GAD). Such results are consistent with emerging evidence[15,20,28–30] and point to a specific risk an anxiety and anxiety disorder in such patients. The present and previous findings relating to depression are more equivocal. Heterogeneity within PD depression may account for some of the inconsistency if younger anxious-depressed patients, representing a distinct phenotypic subtype of depression, are combined in the same sample with older depressed patients without anxiety.[32]

Reasons for an association between anxiety and younger age-of-onset are currently unclear. Early-onset of PD is associated with higher rates of some known genetic mutations. Psychiatric disturbance including anxiety has been reported in 2 parkin gene mutations (PARK2 and PARK7),[41] although the rates may be no higher than in patients without parkin mutations.[42,43] At present, the genetics of anxiety disorder is uncertain, although there appear to be links to the genetics of lifetime trait neuroticism.[44] The onset of GAD can also be associated with traumatic and stressful life events in such susceptible individuals, particularly events involving loss or danger.[45] While PD can be a chronic stressor for all patients, the loss or threat of loss of social, family, and occupational function is typically far greater in those developing the disease earlier in life. This offers 1 plausible mechanism for the observed association between anxiety and young age-of-onset.[46] The findings of the present study linking HADS anxiety to faster rate of motor progression may also be mediated by greater psychosocial stress and loss, rather than a direct association with pathophysiological progression. This latter finding, however, was not replicated in the 2 anxiety-related mood classes and so should be interpreted with caution. Previous studies have also suggested greater degree of depression in patients with more rapidly progressive disease,[10,17,18] although this was not strongly supported by the present results. Examination of longitudinal data from the present cohort will help disentangle the potential contribution of rate of progression to risk of depression and anxiety.

Motor complications of treatment increase in prevalence with disease duration and with the duration and dose of antiparkinsonian treatment. In a prevalent cohort, younger age-of-onset is typically associated with longer duration of disease and treatment and hence a high rate of treatment related motor complications.[41] However, the present study suggests that motor fluctuations make a substantial independent contribution to the prediction of anxiety beyond age-of-onset alone. Some patients report marked anxiety restricted to the off-periods, perhaps representing a specific dopaminergic or dopa-mediated "mood-off" phenomenon.[47] However, the current study focused on anxiety symptoms present more generally over preceding weeks and not simply acute anxiety states synchronized with motor status. The pathophysiological basis of motor fluctuations remains unclear and therefore hard to link to possible shared biological mechanisms with anxiety. However, a nonbiological explanation may be found in the fact that motor-fluctuations are often unpredictable and add significantly to the lack of control that some patients perceive in their day-to-day lives. Intolerance of uncertainty is a trait cognitive bias common in anxiety disorders and particularly GAD. It is associated with high levels of worry and catastrophic predictions plus counterproductive coping behavior.[48] Patients susceptible to motor fluctuations and who find the experience

distressing report "testing" their motor function or "scanning" for signs of an impending off-period that would require a dose of medication. Such attentional focus on, and attempt to control, an often unpredictable event typically serves to maintain state anxiety rather than reduce it. Motor fluctuations may therefore provide a particularly salient stressor that exacerbates anxiety in already anxious individuals rather than reflecting a specific pathophysiological association.

Consistent with previous studies, the univariate data suggests that patients with a tremor-dominant motor subtype tended to be less depressed and to be underrepresented in each of the 3 mood-classes. Such patients tended also to have shorter disease duration, less severe motor symptoms, and less cognitive impairment (Table 2). The regression analysis focused on the overlapping distinction between PIGD and non-PIGD subtypes, and the 2 subclasses of fallers, those with PIF and those with FOG. Previous research[13–16] has indicated an association between such factors and depression, findings that were partially replicated in the present results. Axial symptoms are typically unresponsive to dopaminergic medication and therefore presumed to reflect extra-nigral pathophysiology. By association, the same or parallel mechanisms may also contribute to non-motor symptoms including cognitive impairment and depression, shown to be associated, including in the present sample. For example, axial motor symptoms have been linked to loss of pedunculopontine nucleus (PPN) cholinergic neurons.[49] The role of cortical cholinergic loss in PD dementia is well established[50] and there is in vivo evidence for similar loss related to the severity of depressive symptoms in both demented and nondemented patients, as well as thalamic loss in fallers.[51] Arguing against a role for the cholinergic system in depression is the lack of robust evidence for a significant impact of cholinesterase inhibitors on mood in PD (eg, Thomas et al.[52]), although, to date, there have been no randomized trials with depression as a primary outcome. A second possible mechanism underpinning an association between axial symptoms and depression is white-matter change. White-matter damage is a significant predictor of gait problems and falls in the elderly[53] and is also strongly associated with depression and cognitive impairment.[54] In PD, microstructural white-matter changes are similarly associated with both axial motor and cognitive symptoms,[55] whereas recent in vivo studies report increased white-matter changes in corticolimbic and medial thalamic areas in depressed patients.[6,56]

In contrast to the evidence relating motor subtype to depression in PD, there is limited and inconsistent evidence for an association with anxiety.[12,15,27] Pontone et al.[30] examined the motor characteristics of anxious versus non-anxious people with PD and, although they did not specifically use a motor subtype classification, they did not find any difference in motor features between groups. The present results do not provide any robust evidence for an association between postural instability and anxiety, although in individual patients fear of falling may be a significant source of concern and contribute to activity limitation and social avoidance.[57,58] Already-anxious patients who develop postural instability or who then experience falls may well become more anxious in response to this unpredictable and potentially harmful problem. Such specific anxiety is known to adversely affect anticipatory postural control, further strengthening the relationship.[59] In patients with motor fluctuations, anxiety may also contribute to the escalation in medication use observed in some patients as they seek to ward off impending or anticipated off-periods, or even prompt requests for surgical interventions as a way of seeking to control unpredictable and distressing motor symptoms.

Although the largest study of its type, some limitations of the present study should be acknowledged. The HADS, although a valid measure of depression and anxiety in PD, does not capture all of the symptoms related to syndromal disorder. Second, the absence of a comparison group makes it impossible to assess the impact of age independent of disease factors.

In conclusion, the present results reinforce and extend our understanding of the clinical associations between parkinsonian motor subtypes, depression, and anxiety, and support the importance of considering heterogeneity in exploring possible etiological models. The reported associations do not imply any single causal mechanism. Depression and anxiety are multifactorial with complex and variable factors probably contributing to both onset and symptom maintenance. There is growing evidence for the role of monoamine systems in PD depression.[5] However, when combined with evidence from other sources, the present association findings suggest a possible contribution of the cholinergic system and white-matter change, at least in older non-anxious depressed patients. While specific neurochemical changes may also contribute to trait anxiety in PD, perhaps predating the onset of the motor symptoms, the evidence reported here is also consistent with an additional role for situational (state) factors such as the threat posed by the disease (eg, to younger patients) and its symptoms (eg, motor fluctuations) and their often inherent unpredictability. Such results can have direct clinical relevance. First, they show the potential importance on nonbiological factors in driving, maintaining, or exacerbating anxiety in biologically susceptible individuals. Second, anxiety may interact negatively with a patient's motor state and way they seek to manage their symptoms. Third, a broader biopsychosocial model may usefully guide the evaluation of psychological treatments using methods already used to treat similar anxiety symptoms in non-neurological populations. ■

Appendix

In addition to the listed authors, additional members of the PROMS-PD Study Group made a significant contribution to the work reported in this article: R. Anderson, King's College London, Institute of Psychiatry (participant recruitment, data collection); K.R. Chaudhuri, King's College Hospital NHS Foundation Trust, London (participant recruitment); C. Clough, King's College Hospital NHS Foundation Trust, London (participant recruitment); K. Sellwood, King's College London, Institute of Psychiatry (participant recruitment, data collection); A. Simpson, Institute of Psychiatry, King's College London, London (data collection); B. Thomas, King's College London, Institute of Psychiatry (participant recruitment, data collection); R. Weeks, King's College Hospital NHS Foundation Trust, London (participant recruitment); M. Bracewell, Ysbyty Gwynedd, Bangor (participant recruitment, data collection); G. Gibson, University of Liverpool EMI Academic Unit, St. Catherine's Hospital (participant recruitment, data collection); M. Jones, University of Wales Bangor, Bangor (participant recruitment, data collection); L. Moss, Wythenshawe Hospital, Manchester (participant recruitment, data collection); P. Ohri, Eryri Hospital, Caernarfon (participant recruitment); L. Owen, Wythenshawe Hospital, Manchester (participant recruitment, data collection); J. Playfer, Royal Liverpool and Broadgreen University Hospital Trust, Liverpool (study design); G. Scott, Royal Liverpool University Hospital, Liverpool (participant recruitment); C. Turnbull, Wirral Hospitals NHS Trust, Wirral (participant recruitment); R. van Schaick, University of Liverpool EMI Academic Unit, St. Catherine's Hospital (participant recruitment, data collection); L. Dickinson, Institute for Ageing and Health, Newcastle University, Newcastle upon Tyne (participant recruitment, data collection); and J. Carnell, Institute for Ageing and Health, Newcastle University, Newcastle upon Tyne (participant recruitment, data collection).

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