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Vision, visuo-cognition and postural control in Parkinson's disease: an associative pilot study

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Abstract

Introduction: Impaired postural control (PC) is common in patients with Parkinson's disease (PD) and is a major contributor to falls, with significant consequences. Mechanisms underpinning PC are complex and include motor and non-motor features. Research has focused predominantly on motor and sensory inputs. Vision and visuo-cognitive function are also integral to PC but have largely been ignored to date. The aim of this observational cross-sectional pilot study was to explore the relationship of vision and visuo-cognition with PC in PD.

Methods: Twelve people with PD and ten age-matched healthy controls (HC) underwent detailed assessments for vision, visuo-cognition and postural control. Vision assessments included visual acuity and contrast sensitivity. Visuo-cognition was measured by visuo-perception (object identification), visuo-construction (ability to copy a figure) and visuo-spatial ability (judge distances and location of object within environment). PC was measured by an accelerometer for a range of outcomes during a 2-minute static stance. Spearman's correlations identified significant associations.

Results: Contrast sensitivity, visuo-spatial ability and postural control (ellipsis) were significantly impaired in PD (p =.017; p =.001; and p =.017 respectively). For PD only, significant correlations were found for higher visuo-spatial function and larger ellipsis (r = .64; p = .024) and impaired attention and reduced visuo-spatial function (r = -.62; p = .028).

Conclusions: Visuo-spatial ability is associated with PC deficit in PD, but in an unexpected direction. This suggests a non-linear pattern of response. Further research is required to examine this novel and important finding.

Highlights

- Contrast sensitivity, visuo-constructive ability and visuo-spatial ability are impaired in PD compared to age-matched controls.
- Postural control is associated with vision and visuo-spatial ability in PD but not controls.
- Attention is associated with visuo-spatial ability in PD but not controls.

Introduction

Postural instability is a cardinal motor symptom of Parkinson's disease (PD) and a major contributor to falls, causing significant morbidity and reduced quality of life (1). Postural control (PC) in healthy individuals depends upon contributions from the somatosensory (70%), vestibular (20%) and visual (10%) systems which vary as a function of age (2). Evidence, however, suggests that people with PD are more reliant than healthy controls on visual information for effective postural control (3).

Visual impairments are common in PD and include impaired vision (e.g. reduced visual acuity and contrast sensitivity) as well as visuo-cognitive processing (e.g. visuo-spatial deficits) (4). These more complex visual processes involve cognition, particularly attention (4), and are attenuated in people with PD. Vision and visuo-cognition may be a major contributor to impaired PC and falls risk.

This pilot study examines the relationship between a range of visual, visuo-cognitive and PC outcomes in people with PD and age-matched healthy controls (HC). We hypothesised that PC would relate to selective visuo-cognitive outcomes in PD, and that associations would be bi-directional.

Methods

Participants

This study was embedded within a larger study "Visual Function during Gait in Parkinson's disease: Impact of Cognition and Response to Visual Cues" (Ethical approval from Newcastle and North Tyneside REC 1: 13/NE/0128). A subgroup of twelve participants with PD and ten age-matched HC gave written informed consent. Participants were ≥50 years of age, able to stand unaided and on stable medications. PD participants had a diagnosis of idiopathic PD, as defined by UK Brain Bank criteria, and were Hoehn and Yahr stage I-III. Participants were excluded if they had other neurological or orthopaedic disease or significant memory impairment. Age, sex and body mass index (BMI) were recorded. Cognitive assessment included the Montreal cognitive assessment (MoCA), and attention was measured with the CDR attention battery (United Biosource Corporation, UK). Severity of PD motor symptoms was measured using the Hoehn and Yahr scale and the unified Parkinson's disease rating scale (UPDRS-III). PD participants were assessed approximately 1 hour after medication intake.

Vision and visuo-cognitive assessments

Vision

Binocular LogMAR visual acuity and contrast sensitivity were assessed using Mars Perceptix chart (Mars letter CS chart, Mars Perceptrix™, New York, USA).

Visuo-cognition

Visuo-perception (object identification) was tested using the Visual Object and Space Perception battery (VOSP) incomplete letters (5); visuo-construction (ability to copy a figure) with the CLOX2 (6) and MoCA Item #1 (includes trail making test, cube copying, basic clock drawing); and visuo-spatial (judge distances and location of object within environment) with the CLOX1 (6), Benton judgement of line orientation (JLO) (7), VOSP position discrimination and VOSP dot counting (5).

Postural control

PC was measured using a tri-axial axivity accelerometer placed on the fifth lumbar vertebra. Measurements were recorded using a standardised method (8); participants performed a two-minute quiet static stance (looking straight ahead) with feet a comfortable distance apart within a pre-defined area (400mm x 600mm) and hands by their sides. Measurements of PC were calculated from the acceleration signals, as described by Mancini et al., 2012 (9). Measurements included sway dispersion, as the root mean square relative to the mean (RMS); frequency of sway, highest frequency of sway comprising the 95% of the power (Freq95) and jerkiness of sway (JERK). Parameters were computed independently for the antero-posterior (AP) and medio-lateral (ML) directions of sway. Ellipsis, the area including 95% of the ML and AP acceleration trajectories was also measured (8).

Statistical analysis

Due to non-normal distributions for some variables and the sample size, non-parametric statistics were used. Median and IQR were used to describe all outcomes. To avoid multiple testing, Spearman's correlation was used to examine the association between postural control, vision and visuo-cognition only for outcomes that showed significant between-group differences.

Results

Table 1 shows descriptive data and between-group differences for all variables. Both groups were comparable for age, sex and BMI. Significant between-group differences were evident for contrast sensitivity but not visual acuity.

Visuo-constructive ability was significantly different between groups, as measured by MOCA item #1 (p =.017), with CLOX2 close to statistical significance (p =.059). Visuo-spatial ability was significantly worse in PD compared to HC for CLOX1 (p =.017) with a trend for JLO towards significance (p =.080).

Ellipsis was significantly larger for people with PD compared to HC (p =.025), with values for jerk and jerk antero-posterior were close to statistical significance (p =.080, p =.069 respectively), suggesting

more unstable PC in PD. Associations were evident for PD only. A significant correlation was found for better visuo-spatial function and larger ellipsis (r =.64; p =.024) (Fig 1), and impaired attention and reduced visuo-spatial function (r =-.62; p =.028).

Discussion

To our knowledge, this is the first study to systematically explore a range of visual function and visuo-cognitive outcomes in relation to PC for PD and HC. Despite limited sample size, we found between-group differences and moderately strong association between postural control as measured by ellipsis and visuo-spatial function.

The finding that people with PD had worse contrast sensitivity compared to controls is comparable with previous studies (10). Contrast sensitivity cannot be improved with spectacles, but other changes such as improving environmental lighting and the use of visual cues may enhance contrast and help improve PC. Between group differences were also evident for tasks of visuo-spatial ability, as reported previously (11). There was no difference in performance on VOSP position discrimination and dot counting with both groups performing well on both tasks, with maximum median scores for each group suggesting a ceiling effect for this test.

Association between higher (worse) ellipsis and better visuo-spatial ability (measured by CLOX1) is moderately strong but challenging to interpret. As a measure of centre of pressure excursion, ellipsis denotes the total area of postural sway, and a negative relationship with visuo-spatial ability is therefore most likely. Examination of the scatter plot shows association was influenced by three PD participants who showed high ellipsis but within-range scores for CLOX1. Results tentatively point to a non-linear response to ellipsis (higher ellipsis denoting flexible and responsive postural strategy or alternatively a constrained response), which may relate to compensation for worse visuo-spatial ability by increasing stiffness (12). However, previous work implicates executive function in CLOX1 performance (6), which may be heightened in PD given the dominance of fronto-striatal deficit and produced an interaction we were unable to test for. Further inspection of clinical data for these participants (not shown) revealed that scores for disease severity, visual function and global cognition approximated the group median. Attention was more impaired than the median for two of the three participants suggesting a potential role for attention in this relationship; however replication on a larger sample is required to validate this result. The association between the JLO and attention for PD may reflect the prolonged nature of the task and the effect of attentional deficit.

Strengths of this study are its design and selection of visual and visuo-cognitive tasks to identify differences between PD and HC. The main limitation is the small sample size, which led to us being underpowered to detect between-group differences and unable to control for potential co-founders that may influence findings.

In summary, these preliminary, novel results indicate selective association between visuo-cognition and PC in PD and HC. Future research will examine this selectivity in a larger cohort and test interactions between these complex features of motor control in PD.

Conflicts of interest statement

There are no conflicts of interest to report.

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Table 1: Summary of clinical data collected in HC and PD

	10 HC Median (IQR)	12 PD Median (IQR)	P value
Demographics			
Age	62.5 (55.0, 71.5)	67.5 (60.3, 75.0)	.283
Sex	6 male, 4 female	9 male, 3 female	
BMI	24.6 (22.8, 27.0)	27.8 (24.6, 31.7)	.159
Education (years)	17 (11.8, 18.3)	11 (10.0, 11.0)	**.004***
GDS	0 (0, 1.2)	1.5 (1.0, 5.0)	**.030***
UPDRS III	-	37.5 (21.0, 47.8)	
LEDD	-	327 (163.7, 531.3)	
Vision			
Visual acuity	-0.10 (-0.18, 0.10)	-0.08 (-0.10, 0.04)	.346
Contrast sensitivity	1.72 (1.66, 1.73)	1.66 (1.57, 1.68)	**.017***
Cognition			
MoCA	28.5 (26.8, 30.0)	26 (25.0, 26.8)	**.004***
Attention			
POA	1196.2 (1155.2-1262.4)	1349.5 (1226.3, 1483.7)	**.036***
FOA	197.8 (193.6, 198.5)	187.8 (182.6, 193.3)	**.002***
Visuo-cognition			
Visuo-perceptual			
VOSP incomplete letters	20 (19, 20)	19 (19, 20)	.203
Visuo-constructive			
CLOX2	14 (13.5, 15.0)	13 (12.0, 14.0)	.059
MoCA part 1	4.5 (4.0, 5.0)	4 (2.3, 4.0)	**.025***
Visuo-spatial			
CLOX1	14 (13.0, 15.0)	12 (11.0, 13.0)	**.001***
JLO	28 (25.5, 30.0)	24.5 (20.0, 27.8)	.080
VOSP position discrimination	20 (19.8, 20)	20 (19.3, 20.0)	.821
VOSP dot counting	10 (10, 10)	10 (10, 10)	1.00
Postural control			
Ellipsis	0.00089 (0.00052, 0.0010)	0.00136 (0.0089, 0.0032)	**.017***
Freq95 AP	0.6458 (0.450, 1.165)	0.6708 (0.310, 1.602)	1.00
Freq95_ML	1.167 (1.306, 2.088)	1.0125 (0.727, 2.317)	.228
Jerk	0.0585 (0.0460, 0.745)	0.1019 (0.0520, 0.1463)	.080
Jerk_AP	0.0308 (0.0271, 0.0441)	0.0583 (0.0307, 0.0728)	.069
Jerk_ML	0.0237 (0.0152, 0.0351)	0.0365 (0.0214, 0.0647)	.203
RMS	0.00096 (0.00089, 0.00117)	0.00135 (0.00094, 0.0019)	.140
RMS_AP	0.00088 (0.00067, 0.00105)	0.0011 (0.00077, 0.00154)	.228
RMS_ML	0.00050 (0.00029, 0.00062)	0.00060 (0.00052, 0.00081)	.093

[Bold font denotes significant *p<0.05]

Abbreviations: BMI, body mass index; GDS, geriatric depression scale; UPDRS III, united Parkinson's disease rating scale; LEDD, levodopa daily dose equivalent; MoCA, Montreal cognitive assessment; POA, power of attention, FOA, Fluctuation of attention, VOSP, visual object and space perception battery; JLO, judgement of line orientation; AP, antero-posterior; ML, medio-lateral.

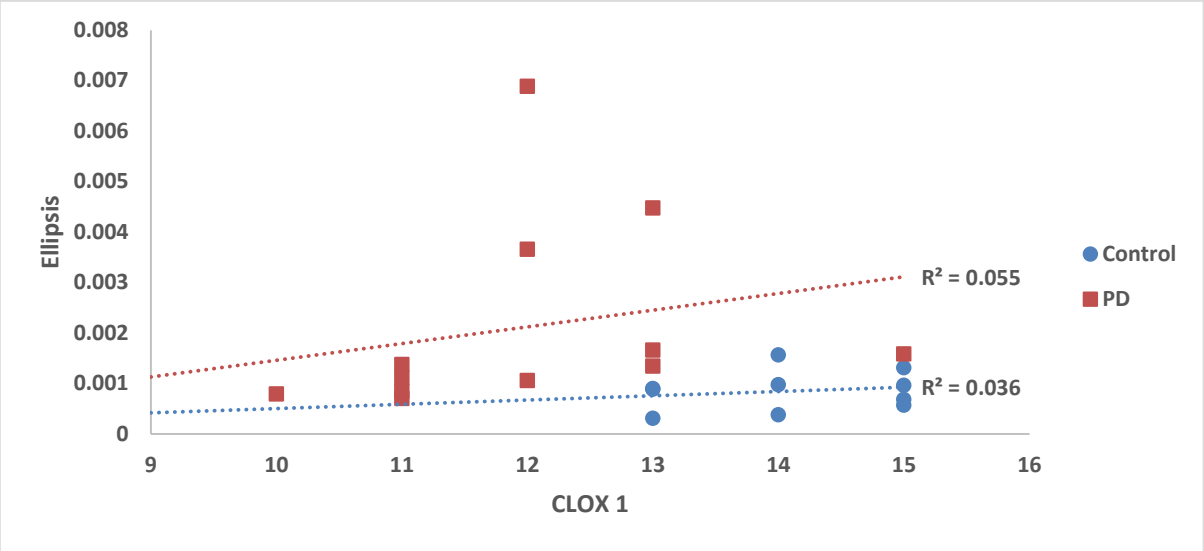

Figure 1: Association between ellipsis and visuo-spatial ability for PD and controls