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Sequence and onset of whole-body coordination when turning in response to a visual trigger: Comparing people with Parkinson's disease and healthy adults

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ABSTRACT

Turning round is a routine everyday activity that can often lead to instability. The purpose of this study was to investigate abnormalities of turning among people with Parkinson's disease (PwPD) through the measurement of sequence of body segments and latency response. Participants were asked to turn 180° and whole-body movements were recorded using CODAmotion and Visio Fast eye tracking equipment. Thirty-one independently mobile PwPD and 15 age-matched healthy controls participated in the study. We found that contrary to common belief, the head preceded movement of all other body segments (eyes, shoulders, pelvis, first and second foot). We also found interaction between group and body segment ($P = 0.005$), indicating that overall, PwPD took longer to move from head to second foot than age-matched healthy controls. For PwPD only, interactions were found between disease severity and body segment ($P < 0.0001$), between age group and body segment ($P < 0.0001$) and between gender and body segments ($P < 0.0001$). For each interaction, longer time periods were noted between moving the first foot after the pelvis, and moving the second foot after the first, and this was noted for PwPD in Hoehn and Yahr stage III–IV (in comparison to Hoehn and Yahr stage I–II); for PwPD who were under 70 years (in comparison with 70 years or over); and for ladies (in comparison with men). Our results indicate that in PwPD and healthy elderly, turning-on-the-spot might not follow the top-to-bottom approach we know from previous research.

1. Introduction

Abnormal posture and mobility are common among people with Parkinson's disease (PwPD) and are important causes of falls and limitations of daily living [1]. Maintaining posture and balance whilst moving relies on a complex interplay of factors [2], and most research into the movement profiles of people turning round has been based on healthy individuals. Evaluation of turning in PwPD has been restricted by small sample sizes: most studies recruited 10 or fewer PwPD with similar numbers of healthy controls [3–8]. Findings have focused on reduced speed, numbers of steps and impaired coordination during rotation. Anastasopoulos et al. [9] described segmental movements of the body during turning in PwPD and related these to movement of the eyes [9]. They suggested that eye movements compensate for trunk slowness during a turn. Hong et al. [3] reported that when medication was withdrawn the head, trunk and pelvis of PwPD had simultaneous onset of movement during rotation, and Ferrani et al. [8] reported delayed initiation of turning movement with altered head and trunk rotational strategy in early stage PD. More knowledge of postural deficits in PwPD is needed to underpin a scientific, evidence-based rehabilitation approach [10].

Difficulty in turning is common in PD [11]. The progressive nature of the condition with dopamine deficiency and reduction in automatic movements can compromise the coordination of multi-segmental tasks such as turning, producing slow and inaccurate movement [12]. Clinicians often describe PwPD as moving en bloc, and reduced axial rotation, restricted head movements and a flexed posture are characteristic of the disease. When standing or walking, attempts to turn can trigger freezing or result in a fall [13–16]. Difficulty when turning is associated with a cluster of gait deficits [17–19] and might have both central (basal ganglia) and peripheral (muscle and joint) causes undermining the timing and quality of movement.

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In healthy adults, it has been suggested that whole-body movements are determined by coordinated eye and head movements and that there is a clear sequence 'from top to bottom' when young healthy individuals perform visually guided tasks that require whole-body orientation [20]. Visual information determines the direction of movement, while coordinated eye and head movements provide a frame of reference to control the movement of the body in space [21]. We proposed that a disruption to these strategies contributes to the postural abnormalities of PwPD whilst turning. The strong link between turning and instability and falls among PwPD [15] highlights the seriousness of the problem. The aim of this study was to investigate the sequence and latency response of body segments (eye, head, shoulder, pelvis and feet) during a 180° turn, in response to a visual trigger.

2. Methods

Ethics approval was obtained from the institutional Research Ethics Committee (Ref. no. SHPRS-ETHICS 08-027). We recruited PwPD through the local Parkinson's UK groups, and their partners were invited to join the study as healthy controls. Participants were screened for study inclusion at home, invited to attend our movement laboratory on one occasion, and gave written informed consent.

2.1. Participants

Participants with PD had a confirmed diagnosis of PD, were independently mobile, and lived in the community. Those with impaired gross cognitive function (mini-mental state examination score <24) [22] or restricted cervical range (observed visually when participants were asked to rotate their head to the left and to the right during the screening visit) were excluded. We recorded UPDRS motor scores [23] and we aimed to recruit 10 people in each of the Hoehn and Yahr I–IV stages [24]; with half non or single fallers and half repeat fallers (a repeat faller is someone who has experienced more than one fall event in the previous 12 months). We defined a fall as an event resulting in a person coming to rest unintentionally on the ground or other lower level, not as a result of a major intrinsic event or over whelming hazard [25]. Healthy controls and PwPD were excluded if they presented with dizziness, vestibular dysfunction, vision impairments that could not be corrected with glasses, or other neurological conditions.

Out of the 71 PwPD who responded to our invitation to participate in the study, six individuals were not eligible, eight withdrew after the home visit and there were 11 exclusions due to equipment related difficulties. Forty-six participants were included in the study (Table 1, upper part). Of the 31 PwPD [mean (SD) age 68 (8) years, mean (SD) duration of PD 7 (4) years, mean (SD) motor UPDRS score 16 (6)); 21 had mild disease (Hoehn and Yahr I–II) and 11 moderate disease (Hoehn and Yahr III–IV); 13 were repeat fallers; and 16 were freezers. We defined a freezer as someone who experienced freezing of gait [FOG], that is, an episodic involuntary inability to generate or maintain walking, at least once a week (freezer score >1 on item 3 of the FOG questionnaire [26]). We recruited 15 age-matched healthy controls [mean (SD) age 67 (8) years).

2.2. Protocol

Participants were tested approximately midway through their medication cycle to ensure optimum mobility. Prior to testing, participants self-reported their preferred direction of turning: two thirds of both groups preferred to turn to the right (Table 1, upper part). Participants were asked to perform visually cued turning-on-the-spot in standing at self-selected speed. A safety belt was placed around the waist of each individual for fall prevention during testing. Whole body movement during the turns was recorded

Table 1
Characteristics of healthy controls and people with Parkinson's disease (PwPD), and for our sample with PD, characteristics of people with mild and moderate PD.

		Healthy controls ($n=15$)	PwPD ($n=31$)	Hoehn & Yahr I–II mild ($n=20$)	Hoehn & Yahr III–IV moderate ($n=11$)
Demographic and disease characteristics. Figures are number (%) unless stated otherwise					
Age	Mean (SD)	67 (8)	68 (8)	67 (8)	71 (7)
	Min–Max	52–80	47–80	47–77	61–80
	<70 years	8 (53%)	18 (58%)	12 (60%)	6 (55%)
	≥70 years	7 (47%)	13 (42%)	8 (40%)	5 (46%)
Gender	Men	5 (33%)	17 (55%)	14 (70%)	3 (27%)
	Ladies	10 (67%)	14 (45%)	6 (30%)	8 (73%)
Self-reported preferred direction of turn: right	10 (67%)	20 (65%)			
Hoehn & Yahr	I		10 (32%)		
	II		10 (32%)		
	III		9 (29%)		
	IV		2 (7%)		
Repeat faller		13 (42%)	7 (35%)	6 (55%)	
Freezer		16 (52%)	10 (50%)	6 (55%)	
Latencies (seconds) for each body segment. Figures are mean (standard error)					
Preferred	Eyes	0.531 (0.043)	0.554 (0.036)		
	Head	0.444 (0.034)	0.523 (0.030)		
	Shoulders	0.439 (0.032)	0.537 (0.030)		
	Pelvis	0.553 (0.038)	0.725 (0.038)		
	First foot	0.694 (0.041)	0.925 (0.074)		
	Second foot	1.092 (0.066)	1.479 (0.108)		
Un-preferred	Eyes	0.497 (0.025)	0.599 (0.034))		
	Head	0.414 (0.016)	0.521 (0.021)		
	Shoulders	0.391 (0.017)	0.528 (0.025)		
	Pelvis	0.420 (0.027))	0.525 (0.021)		
	First foot	0.648 (0.035)	0.936 (0.070)		
	Second foot	1.100 (0.094)	1.489 (0.123)		

[a] 26 participants for preferred direction second foot latency
[b] 12 participants for preferred direction second foot latency