Gait & Posture 49 (2016) 7–13

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Assessing stability in mild and moderate Parkinson's disease: Can clinical measures provide insight?

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ARTICLE INFO

Article history:
Received 26 January 2016
Received in revised form 3 May 2016
Accepted 3 June 2016

Keywords:
Parkinson's disease
Motor control
Falls
Quality of life
Postural stability

ABSTRACT

This cross-sectional study aimed to investigate the relationship between accelerometer-derived measures of movement rhythmicity and clinical measures of mobility, balance confidence and gait difficulty in people with Parkinson's disease (PD). Twenty-nine independently-living PD patients (Hoehn & Yahr Stages 1–3) with no history of significant injury or orthopaedic/deep brain stimulation surgery were recruited from a database of patients who had expressed an interest to participate in research. Participants completed clinical assessments of mobility, postural stability, balance confidence and symptom severity, while head and trunk rhythmicity was evaluated during gait using accelerometers. Following data collection, patients were stratified based on disease stage into either a Mild (Hoehn & Yahr Stage 1) or Moderate (Hoehn & Yahr Stages 2–3) PD group. The results highlighted that the Moderate PD group had poorer quality of life, reduced balance confidence and increased gait and falls difficulty. Furthermore, for these patients, gait disability and the number of previous falls were both negatively correlated with multiple components of head and trunk rhythmicity. For the Mild PD group, six-meter walk time was positively correlated with ML head rhythmicity and linear regression highlighted a significant predictive relationship between these outcomes. For the Mild and Moderate PD groups, balance confidence respectively predicted anterior-posterior trunk rhythmicity and vertical head rhythmicity. While these findings demonstrate that falls history and the Gait and Falls questionnaire provide moderate insight into head and trunk rhythmicity in Moderate PD patients, objective and clinically-feasible measures of postural instability would assist with the management of these symptoms.

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1. Introduction

Postural instability is one of the most disabling symptoms of Parkinson's disease (PD) and significantly increases the risk of falling [1]. The costs of falls and falls-related injuries are not well established for many countries [2], but Australian estimates indicate that approximately AUD$27.5 million was spent on injuries associated with falls and falls-related injuries in 2010 [3]. Given the significant physical and financial burden associated with falls in PD, a clear need exists to develop an improved capacity to assess symptoms of postural instability to assist with their early identification and treatment. For people with PD, symptoms of postural instability are often accompanied by a decline in the patient's mobility [4]. Traditionally, clinical tests like the Timed up and Go (TUG) [5] and 10-m [4] (or 6-m [6]) walk tests have been used to assess changes in mobility for a range of healthy [7] and pathological [4] populations. Given the ease with which they can be administered and their widespread use in hospitals and other clinical settings, it is not surprising that such tests are often used to assess the efficacy of exercise interventions aimed at improving mobility and/or preventing falls in people with PD [8]. However, despite their widespread use for the assessment of people with PD [9], research suggests that some of these clinical tests are not always able to identify differences in mobility between people with PD and age-matched controls [10,11]. Therefore, while the TUG and 6-meter walk tests are widely acceptable as clinical tests

Abbreviations: ABC, Activities-Specific Balance Confidence Scale; ACE, Addenbrooke's Cognitive Examination; PD, Parkinson's disease; TUG, Timed up and Go test; UPDRS, Unified Parkinson's Disease Rating Scale.

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http://dx.doi.org/10.1016/j.gaitpost.2016.06.002
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of mobility, there seems to be a need for further investigations to determine whether such clinical tests have the capacity to identify changes in postural stability in people with PD.

The improved availability and affordability of wearable sensors has now made it feasible to develop and/or enhance clinical assessments to incorporate more objective measures of walking stability. For example, research has shown that by placing a wearable sensor on a patient's body during the performance of the TUG test, the objectivity of the assessment can be significantly improved [11]. Specifically, research utilising this adaptation of the TUG test has reported differences in the amplitude, rhythmicity and smoothness of segmental motion (as measured using RMS accelerations, harmonic ratios and jerk, respectively) for people with PD compared with age-matched controls [12]. Of the numerous accelerometer-based outcomes reported in the literature, the harmonic ratio (HR) is the most commonly reported for people with PD [13] and provides a measure of gait rhythmicity by assessing the ratio of in-phase accelerations to out-of-phase accelerations within a given gait cycle [14]. Additionally, the HR has been shown to have the capacity to discriminate PD patients with a history of falling from patients who have not previously fallen [15]. Despite its frequent use in the research setting, more traditional tests of mobility continue to prevail in daily clinical practices. As such, this study aimed to determine whether the results of common clinical tests of mobility, balance confidence and gait difficulty correlate with laboratory-based measures of postural stability to determine whether these assessments offer insight into deficits in postural stability for people with PD. It was hypothesised that clinical measures of mobility, gait difficulty, postural stability and balance confidence would not be related to movement rhythmicity and, therefore, offer limited insight into dynamic postural stability.

2. Methods

2.1. Participants

Thirty participants diagnosed with idiopathic PD, based on the UK Brain Bank Criteria were recruited. Patients with a history of two or more near-misses and/or at least one fall in the previous 12 months were contacted via a pre-existing database of people with PD who had expressed an interest to participate in research. Prospective participants received an information letter outlining the study's details and inviting them to contact a member of the research team if they were interested in volunteering. Participants were excluded if they were; (i) unable to stand and walk independently; (ii) significantly visually (Bailey-Lovie high contrast visual acuity >0.30 logMAR) or cognitively impaired (Addenbrooke's cognition examination score <82); (iii) known to have uncontrolled hypertension; (iv) taking psychotropic medications; (v) significantly limited by osteoporosis; (vi) a recipient of orthopaedic surgery within the previous year; (vii) suffering serious neck, shoulder or back injuries (including spinal fusions); or (viii) a recipient of deep brain stimulation surgery to manage their symptoms. Experimental procedures were approved by the University's Human Research Ethics Committee and volunteers provided written informed consent. An a-priori sample size calculation based on a p-value of 0.05, a power of 80% and a large effect size ($\rho = 0.6$) indicated that at least 13 participants were required per group to examine the relationships between the clinical tests and harmonic ratios.

2.2. Experimental protocol

Individuals attended a single testing session during which a battery of tests was performed including clinical assessments of; (i) cognition (Addenbrooke's Cognitive Examination (ACE)); (ii) visual acuity (Bailey-Lovie high contrast visual acuity); (iii) symptom severity (Unified Parkinson's Disease Rating Scale (UPDRS), the modified Hoehn & Yahr (H&Y) scale, the Schwab & England Activities of Daily Living Scale, the PD Gait and Falls questionnaire and the Freezing of Gait (FOG) questionnaire); (iv) balance confidence (Activity-specific Balance Confidence (ABC) scale); and (v) quality of life (39-item Parkinson's Disease Questionnaire (PDQ-39)). A measure of postural instability and gait disability (PIGD) was also calculated for each participant by summing items 27–30 of the UPDRS motor sub-section [16]. The ACE was used to assess cognition, as it incorporates the Mini Mental State Examination and has high sensitivity and specificity for detecting dementia (cut-off score of <82 gives 82% sensitivity and 100% specificity). These assessments were selected due to their established reliability, validity [17,18] and previous use in assessing individuals with PD [19]. In addition to the clinical assessments, participants were also asked to report any falls and/or near misses experienced in the previous year. For this study, a fall was defined as "any coming to the ground or other lower level not as the result of a major intrinsic event or overwhelming hazard [20]". A near miss was defined as "an event on which an individual felt that they were going to fall but did not actually do so [20]".

Following the questionnaire-based assessments, participants completed five barefoot trials of the TUG test. Participants were seated in a 42 cm high chair with their feet flat on the floor, their back flat against the backrest and their arms resting on the armrests, which were situated 20 cm above the seat. Upon the word 'GO,' participants were required to stand from the chair and walk at a brisk, but comfortable pace to a line on the floor three meters away, turn around and return to the chair to sit down. The time taken to complete the test was recorded using a stopwatch. Following the TUG test, participants completed 6 barefoot walking trials at a comfortable pace along a 10-m firm walkway. In accordance with the established procedures of the 6-m walk test (6MWT), walking speed was assessed over the middle 6-m distance using a dual beamed timing gait system (SWIFT Performance Equipment, Alstonville, Australia) that was positioned at hip height.

Gait rhythmicity was assessed during the 6MWT using two microelectromechanical (MEMS) three-dimensional accelerometers (1500 Hz; Noraxon Inc., Scottsdale, AZ) to provide insight into the patients' dynamic postural control. Each accelerometer was statically-calibrated prior to attachment by aligning each of its sensing axes perpendicular to a horizontal surface to establish the exact value of gravitational acceleration (i.e. 1 gravitational unit or 1 g) [14]. Following static calibration, one accelerometer was firmly attached to a sport headband and positioned over the occipital protuberance and the second accelerometer was firmly attached using double-sided tape to the skin overlying the spinous process of the 10th thoracic vertebra (T10) and reinforced with Micropore. During the 6MWT trials, 3D head and trunk accelerations were wirelessly telemetered to a Telemyo DTS unit, which was connected to a laptop computer running the MyoResearch XP (v1.08) software.

2.3. Data analysis

Raw accelerations were transformed to represent a horizontal-vertical orthogonal coordinate system [14]. Transformation was necessary, as accelerometers measured data relative to a local (or internal) rather than global coordinate system. As such, positioning sensors on body segments often results in two or more of the sensing axes being influenced by gravitational accelerations, which can make it difficult to identify the proportion of the signal attributable to movement-related accelerations [14]. After data

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