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Are factors related to dual-task performance in people with Parkinson's disease dependent on the type of dual task?

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ABSTRACT

Background: Impaired dual-task performance significantly impacts upon functional mobility in people with Parkinson's disease (PD). The aim of this study was to identify determinants of dual-task performance in people with PD in three different dual tasks to assess their possible task-dependency.
Methods: We recruited 121 home-dwelling patients with PD (mean age 65.93 years; mean disease duration 8.67 years) whom we subjected to regular walking (control condition) and to three dual-task conditions: walking combined with a backwards Digit Span task, an auditory Stroop task and a Mobile Phone task. We measured dual-task gait velocity using the GAITRite mat and dual-task reaction times and errors on the concurrent tasks as outcomes. Motor, cognitive and descriptive variables which correlated to dual-task performance ($p < 0.20$) were entered into a stepwise forward multiple linear regression model.
Results: Single-task gait velocity and executive function, tested by the alternating intake test, was significantly associated with gait velocity during the Digit Span ($R^2 = 0.65$; $p < 0.001$), the Stroop ($R^2 = 0.73$; $p < 0.001$) and the Mobile Phone task ($R^2 = 0.62$; $p < 0.001$). In addition, disease severity proved correlated to gait velocity during the Stroop task. Age was a surplus determinant of gait velocity while using a mobile phone.
Conclusion: Single-task gait velocity and executive function as measured by a verbal fluency switching task were independent determinants of dual-task gait performance in people with PD. In contrast to expectation, these factors were the same across different tasks, supporting the robustness of the findings. Future study needs to determine whether these factors predict dual-task abnormalities prospectively.

1. Introduction

Compared to healthy elderly, people with Parkinson's disease (PD) generally show greater problems when performing dual tasks [1]. Loss of automaticity as a result of basal ganglia dysfunction and cognitive impairment may underlie dual-task (DT) deficits in PD [2,3]. Several studies showed that DT performance in PD was significantly associated to falling [4], gait quality [1], freezing [5], disability [6] and disease severity [6], illustrating its direct relation to functional mobility. Assessing determining factors of DT performance that are easy to administer and time-saving for clinical practice is therefore important.

So far, few studies looked at determinants of DT gait performance in PD. Depression, fatigue and executive function were found to predict both single-task (ST) and DT gait velocity when carrying a tray with glasses [7]. In a study on 153 PD patients [8], 34% of the variance of DT gait velocity was explained by increased fear of falling, disease severity, medication and depression. When calculating DT interference as a percentage of ST gait velocity, only 12% of the variance was explained by disease severity and impaired executive function [8]. Finally, when different cognitive domains were investigated in relation to specific spatiotemporal gait

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parameters during ST and DT walking in PD, gait velocity and stride length correlated with processing speed [9], while postural features, such as step width, were influenced by executive function [9].

In older people, usual walking abilities and cognitive function were demonstrated to contribute to DT gait outcomes [10]. Relationships, however, depended on the nature of the dual task, the gait feature being studied and the particulars of the cognitive domain involved [10,11].

So far, no studies have investigated the determinants of DT performance in PD, addressing both motor and cognitive dependent variables using a variety of concurrent tasks. Therefore, the first aim of this study was to identify the factors that are associated with motor and cognitive DT outcomes in three different dual tasks in people with PD. We hypothesized that ST performance, cognitive function and age would be important contributors of DT performance [8,10,11]. A second aim of this study was to assess whether determinants of DT performance were task-dependent, as was previously found in the elderly [10].

2. Methods

2.1. Participants

Data were collected as part of the DUALITY trial, investigating the efficacy of DT training in PD [12]. Inclusion criteria were: (a) diagnosis of PD according to the UK Brain Bank criteria [13]; (b) Hoehn and Yahr (H&Y) stage ≤ 3 in the ON-phase of the medication cycle [14]; (c) ability to walk for 10 min continuously; (d) presence of DT effects as established by a structured checklist; (e) a score ≥ 24 on the Mini Mental State Examination (MMSE) [15]; (f) stable medication over the past 3 months; (g) no hearing or visual problems that interfere with testing or training; and (h) stable deep brain stimulator (DBS) settings over the past year. Ethical approval for the study was obtained in both centers participating in the study (Belgium: CME KU Leuven – B322201213165/S53419 and the Netherlands: CMO Regio Arnhem-Nijmegen – NL39530.091.12). The DUALITY trial was registered in clinicaltrials.gov (NTC01375413). Informed consent forms were signed by patients before study participation.

2.2. Dependent and independent variables

A detailed description of the clinical test battery was published earlier [12]. For the present study, only data from the first baseline test were used. Table 1 shows the independent variables divided in three categories: 1) descriptors, 2) cognitive measures, and 3) motor outcomes. Age, disease duration, freezing (yes/no), levodopa-equivalent dose (LED) [16] and the presence of DBS were recorded as patient descriptors. Cognitive ability was assessed using Mini Mental State Examination (MMSE) [15], Montreal Cognitive Assessment (MoCA) [17], Frontal Assessment Battery (FAB) [18] and Scales for Outcome in Parkinson's disease – Cognition (ScopaCog) [19]. In addition, we performed two executive verbal fluency tests: 1) the Alternating Names Test (ANT) [20] in which 10 boy's and girl's names had to be given alternatingly and 2) the Alternating Intakes Test (AIT) [20] which involved naming 10 foods and drinks while switching between categories. Disease specific motor assessments included H&Y stage [14] (ON- medication), Unified Parkinson's disease rating scale – part 3 (UPDRS-III) [21], Freezing of Gait questionnaire (FOGQ) [22] and Activities specific Balance Confidence scale (ABC) [23]. Gait velocity (cm/sec) at preferred speed was assessed with the GAITRite Walkway System [24] during ST and DT performance. Walking started and ended 1 m before and after the mat after a verbal signal. Concurrent tasks consisted of 1) the backwards Digit Span task, 2) the auditory Stroop task and 3) the Mobile Phone task, starting at the same time as walking. The number of digits in the backward Digit Span task, verbally repeated in reverse order, were adapted to the individual's ability [25] and conveyed via headphones (Beyerdynamic; transmitter: t-bone DS16T – receiver: t-bone IEM100R). Numbers were provided to the participant once the verbal signal to walk was given. The same headphones were used for the Stroop task in which subjects had to verbally respond to the words “high” and “low” pronounced with congruent or incongruent high and low tones. Stimuli were presented with a variable interval (1.5–2 s) to control for cueing effects. Concurrent Digit Span and Stroop tasks were assessed in three different versions that were repeated twice in each condition. For the functional Mobile Phone task, patients were asked to type the test date into a mobile phone with large buttons (Emporia Talk Premium; Austria). This task was repeated twice under ST and DT conditions. Concurrent tasks were assessed in sitting and walking in a random order. Patients were instructed to concentrate equally on both tasks during DT walking.

Cognitive task performance (Digit Span and Stroop task), performed in sitting and walking, was calculated as reaction times and error rates. Verbal responses were recorded through the same channel as the sound fragments using Audacity 1.3 Beta software and reaction times were calculated using a custom-made script with Matlab R2011b software (See Supplementary material 1). Mobile Phone task performance was calculated as the number of errors.

We built regression models for the following dependent variables (Table 1): Gait velocity while performing 1) the Digit Span, 2) the Stroop and 3) the Mobile Phone task; reaction times of the 4) Digit Span and 5) Stroop task when walking; and errors (yes/no) on the 6) Digit Span, 7) Stroop and 8) Mobile Phone task when walking. Dependent variables were based on absolute outcomes only and not on % interference measures. However, to compare differences in task load and prioritization between the three concurrent tasks, we also calculated DT effects as the difference between ST and DT performance expressed as a percentage of ST performance (See Supplementary material 2).

2.3. Statistical analysis

IBM SPSS version 22 (IBM corp., Armonk, NY, USA) was used for data analysis [26] Missing data were due to technical problems and occurred in 3.31–4.95% of cases. We built regression models for absolute DT values rather than for DT effects, as the latter were found to be less stable in a recent reliability study [27].

Univariate correlations between dependent and independent variables were assessed using simple linear regression models [26]. Potential determinants (Table 2) were included in a multivariate linear regression model if they had a p-value of less than 0.20 [26]. To avoid multi-colinearity (Pearson correlation coefficient exceeding 0.70), we only entered the determinant with the highest correlation [26]. A stepwise forward regression procedure was performed to obtain a limited number of significant factors [26]. Distribution, linearity, homoscedasticity and independency of the residuals were plotted and checked visually. In case of binary outcomes (error scores), we performed a stepwise forward (likelihood ratio based) binary logistic regression [26].

3. Results

Descriptive data are presented in Table 1. One-hundred and twenty one participants were included in the analyses. In the subjective best ON-phase of the medication, eighty patients were classified as H&Y stage 2 and 40 as stage 3. Data from 1 patient was missing. Supplementary material 2 shows that DT effects were significantly greater for gait than for the concurrent tasks,