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Original article

PERFORMANCE OF OBSTACLE STEPPING IN PATIENTS WITH PARKINSON`S DISEASE

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Abstract

Aim: The aim of this study was to investigate the acquisition and performance of a more complex bilateral obstacle stepping task compared to unilateral obstacle stepping in Parkinson's disease (PD) patients and healthy age-matched control subjects.

Preliminary evidence evidence suggests that impaired force control during walking may contribute to freezing episodes, with difficulty to unload the swing leg and initiate the swing phase, we used external loading to manipulate force control and to investigate its influence on freezing of gait.

Methods: We used obstacle stepping and trendmill. Gait tasks were used to provoke freezing episodes, quantified using blinded, videotaped clinical assessment. Reading the literature. Observation.Tests.Trials.

Results: The subjects were informed about the experiments and gave written consent. 15 patients with PD and 15 age-matched healthy subjects participated. Inclusion criteria for the patients were the diagnosis of idiopathic PD according to the UK Parkinson's disease Brain Bank criteria and Hoehn and Yahr stages 1.5-3. Only subjects who were able to walk unassisted on the treadmill at a speed of 2 km/h were included.

We evaluated:

-the ability of PD patients to acquire and perform a high-precision bilateral locomotor task.

*Conclusions:*Task performance improved with repetition in both PD and healthy subjects. This suggests a motor learning in both groups but depending on the task investigated, it was suggested that a dysfunction of the basal ganglia resulted in a difficulty to switch between motor programs.

Key terms: Parkinson's disease, obstacle stepping, locomotor task.

Introduction

Parkinson's disease (PD) is characterized by deficits in motor control, such as difficulties in movement initia•tion (Rocchi, et al. 1996), scaling movement amplitudes (Jackson, et al. 2001) or modulating muscle activity (Flament et al. 2003, Pfann et al. 2001). Movement performance was shown to strongly deteriorate with increasing complexity in upper limb movements (Krebs, et al. 2001).

Furthermore, an increased movement time and variability as well as decreased movement velocity occur in bilateral arm and finger movements (Lazarus, 1996; Shimizu, et al. 1987). PD subjects also have difficulties in gait initiation (Krystkowiak, et al. 2006; Rocchi et al. 1996), adapting to disturbances (Roger, 1987), and they walk with short strides and fall frequently in advanced disease stages (Bloem, et al. 2001). In a previous study the acquisition and performance of unilateral obstacle stepping was evaluated in PD patients (Burleigh-Jacobs, et al. 1997; Bloem, et al. 2001). Patients' performance was initially poorer and improved more slowly than healthy subjects.However, after task repetition the performance became similar in both groups.

In upper limb studies (Lazarus, 1996; Shimizu, et al. 1987), PD subjects experienced greater difficulties in the performance of complex bilateral tasks compared to healthy subjects.

Therefore, it was of interest to evaluate to what extent a more complex lower limb locomotor task, i.e., bilateral obstacle stepping, reveals stronger deficits. Such a task requires major demands on the interaction between anticipatory postural adjustments and voluntary control ofleg movements.

A defective coordination of upper and lower limbs (Swinnen, et al. 1997, Winogrodzka, et al. 2005) combined with abnormal postural reactions (Roger, 1987) might lead to larger problems in the perfor•mance of the bilateral compared to the unilateral obstacle stepping task. Furthermore,

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an impaired use of feedback information (Verschueren, et al. 1997) in connection with a reduced kinaesthetic sensation (Demirci, et al. 1997) might also negatively influence the more complex task performance.

Therefore, the aim of this study was to investigate the acquisition and performance of a more complex bilateral obstacle stepping task compared to unilateral obstacle stepping in PD patients and healthy age-matched control subjects. On the basis of previous studies looking at the performance of bimanual tasks in PD patients, we hypothesized that a poorer acquisition and performance in these subjects would be seen compared to unilateral obstacle stepping and healthy subjects

Methods

The subjects were informed about the experiments and gave written consent. 15 patients with PD and 15 age-matched healthy subjects participated. Inclusion criteria for the patients were the diagnosis of idiopathic PD according to the UK Parkinson's disease Brain Bank criteria and Hoehn and Yahr (HY) stages 1.5-3. Only subjects who were able to walk unassisted on the treadmill at a speed of 2 km/h were included. In addition, before starting the experiment, the subjects performed three test trials in order to determine their ability to perform the obstacle stepping task. The data of these subjects were included into the analysis.

Excluded criteria:

- Subjects with other associated neurological, cardiovascular and psychiatric diagnoses as well as those with L-dopa induced hallucinations were excluded and MMSE less that 27.

The average age of the PD patients was 71.2 years (standard deviation (SD)= 8.5). They weighed 75.8kg . The healthy subjects had an average age of 62.4 years (SD= 9.2), weighed 69.6kg (SD= 10.8) and were 170cm (SD =6.9) tall. There was no statistical difference between the two subject groups.

Inclusion criteria: patient must be in best ,,ON''after LDopa ingestion

Table1 Characteristics of patients with Parkinson's disease

Sex	Age (y)	mH Y	Duration of PD (Y)	UPDRS (III)	UPDRS (I-IV)	Medication
M	71	3	8	28	38	800MG L-DOPA
M	63	2	3	15	16	700MG L-DOPA
F	70	2.5	10	18	24	600MG L-DOPA
F	61	2.5	7	14	24	600MG L-DOPA
M	79	3	12	30	36	800MG L-DOPA
M	60	2	5	17	33	600MG L-DOPA
F	56	2.5	9	26	41	800MG L-DOPA
M	61	2	7	20	35	800MG L-DOPA
F	67	3	15	25	32	700MG L-DOPA
M	55	3	12	20	32	800MG L-DOPA
M	56	2	8	40	56	600MG L-DOPA
M	69	3	9	41	51	1000MG L-DOPA
M	69	2.5	5	28	30	700MG L-DOPA
M	50	2	4	15	31	800MG L-DOPA
M	66	2.5	6	20	38	600MG L-DOPA
M	55	2.5	7	15	29	700MG L-DOPA
M	61	3	9	12	16	800MG L-DOPA
Mean	71.2	2.8	9.06	24.4	37.4	

F Female; M Male; PD Parkinson's disease; mHY modified Hoehn and Yahr scale; UPDRS Unified Parkinson Disease Rating Scale; UPDRS Ill Motor examination of UPDRS; LED-Levodopa equivalent doses

General procedures and data recordings

Subjects walked on a treadmill with a speed of 2 km/h and freely moving arms. Obstacle were placed next to the, in order to study the bilateral obstacle stepping. The obstacles consisted of a foam stick fixed 14 cm above the treadmil.

Thus, the subjects were not able to predict when an approaching obstacle would appear, or which side the obstacle would approach from. After subjects had stepped over the obstacle, it folded up at the end of the treadmill and returned to its start position.

The learning task consisted of repetitively stepping over the obstacles.

The number of obstacle hits was recorded by the kinetoterapist..

The whole experiment consisted of two blocks of trials, each consisting of 40 steps over the obstacles (i.e., 20 obstacle steps with each leg). Between the two blocks the subjects had a break of 10 minutes..

An improvement of performance during repetitive obstacle stepping was defined by: (1) a lower level of foot clearance, and (2) a decrease in the number of obstacle hits.

All statistical calculations were performed using a 2-way analysis of variance (ANOVA) for repeated measures.
To determine differences in foot clearance between onset and end of each block, the measure• ments of the first and last 6 steps of all subjects were taken for analy• sis.

The factors condition (4 levels: onset and end of the first and sec• ond block, respectively) and group (2 levels: PD and healthy subjects) and their interaction were included in the model.

Results

A separate analysis of the right and left leg of all subjects showed no difference between legs. Therefore, results obtained from both legs were pooled together.

Foot clearance data were removed when the subjects touched the obstacle (healthy subjects: block 1: n = 39, block 2: n=30; PD subjects: block 1: n=59, block 2:n = 39;

Course of task performance

During the acquisition of the bilateral obstacle stepping task, the healthy subjects improved foot clearance faster than PD patients.

During the obstacle steps, there was no difference in the swing phase duration between PD and healthy subjects (mean swing phase duration: PD subjects: 0.65 s, SD=0.12; healthy subjects: 0.75s, SD=0.10; P=0.097).

In addition, no adaptation in swing phase duration occurred during both blocks of trials in the two groups.

The averaged foot clearance onset and end values differed between groups and conditions.

Both subject groups started the experiment at the same level of foot clearance, improved foot clearance significantly (P < 0.001). However, at the end of block 1, healthy subjects performed better than PD subjects (P = 0.004). Similarly, in block 2, the onset values were better than PD subjects (P = 0.004)

Discussion

The aim of this study was to evaluate the ability of PD patients to acquire and perform a high-precision bilateral locomotor task. A deterioration of performance from the unilateral to the bilateral obstacle task was expected, based on previous results of patients performing complex bilateral hand movements [13, 25].

The main observations were the following: (1) Foot clearance improved in the PD and healthy subjects during the acquisition of the task. However, improvement was slower and performance was poorer in PD subjects. (2) The healthy subjects tended to hit the obstacle less frequently compared to the PD subjects.

Like othe studies, In upper limb studies (Lazarus, 1996, Shimizu, et al. 1987), PD subjects experienced greater difficulties in the performance of complex bilateral tasks compared to healthy subjects.

Therefore, it was of interest to evaluate to what extent a more complex lower limb locomotor task, i.e., bilateral obstacle stepping, reveals stronger deficits.

Such a task requires major demands on the interaction between anticipatory postural adjustments and voluntary control ofleg movements.

A defective coordination of upper and lower limbs (Swinnen et al. 1997, Winogrodzka, et al, 2005) combined with abnormal postural reactions (Roger, 1987) might lead to larger problems in the performance of the bilateral compared to the unilateral obstacle stepping task. Furthermore, an impaired use of feedback information (Verschueren, et al. 1997) in connection with a reduced kinaesthetic sensation (Demirci, et al. 1997) might also negatively influence the more complex task performance.

Some PD subjects were only able to perform the experiment by holding onto the parallel bars, leading to reduced balance demands. A separate examination revealed a similar improvement in foot clearance and number of obstacle hits compared to the PD subjects with freely moving arms.

Finally, the clinical parameter UPDRS III (motor ex• amination) showed a correlation to the number of error trials during bilateral obstacle stepping (i.e., obstacle hits), but not to the improvement in task performance.

This result suggests that this clinical score might at least partially be suitable to assess the ability of PD subjects to perform such a functionally demanding task as investigated in the present study.

Conclusions

The present findings support the hypothesis that patients with mild to moderate PD suffer from an impaired acquisition and performance of a high-precision locomotor task, such as bilateral obstacle stepping.

During task repetition, improvement is slower and performance level is poorer in PD subjects compared to healthy subjects. However, PD subjects were able to improve their performance during the course of the experiment to some extent.

Therefore, the results support the sugges• tion that PD subjects suffer from greater difficulties in daily life situations due to difficulties in locomotor be• havior when attention has to be shared. However, adequate training can improve their adaptive locomotor behavior.

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