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Effects of bilateral subthalamic stimulation on gait kinematics and kinetics in Parkinson's disease

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Abstract. Subthalamic nucleus (STN) stimulation, a recent surgical approach to Parkinson's disease (PD), has been shown to be effective in relieving motor symptoms. The present study carried out a full body gait analysis, during overground walking, on ten PD patients with bilaterally implanted STN stimulation devices. Walking performance was analyzed on the same day, in four conditions (Stim Off Med Off, Stim On Med Off, Stim Off Med On, Stim On Med On). The results showed that, on average, STN stimulation alone (S+M⁻) and L-dopa alone (S-M⁺), significantly increased gait speed, stride length and the lower limb joint Range of Motion (ROM) with respect to the basal condition (S-M⁻); also cadence

was found to play a role in velocity increase, particularly when L-dopa was administered. Both treatments improved pelvis and trunk kinematics, and power production at the ankle and hip joints. The combination of the two treatments (S+M⁺) produced an additional effect on gait speed, stride length, ROM of knee and ankle joints, pelvis obliquity and trunk inclination. Given the additive and synergistic effects, it can be hypothesized that the two treatments have different mechanisms of action. Our results confirm the findings of earlier studies that employed treadmill walking.

Keywords Gait analysis · Parkinson's disease · Subthalamic nucleus stimulation · Deep brain stimulation · Motor rehabilitation

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Introduction

Recently the surgical therapy for advanced PD, characterized by motor fluctuations, dyskinesias and a remarkable disability (Schrag and Quinn 2000), has been revalued, especially after the development of Deep Brain Stimulation (DBS).

DBS of the subthalamic nucleus (STN) appears very effective in controlling PD rigidity, akinesia and tremor (Hallett and Litvan 1999; Pollak et al. 1998; Kumar et al. 1999), allowing a significant reduction of dopaminergic therapy with a consequent remarkable improvement of involuntary movements (Limousin et al. 1998; Moro et al. 1999; Lopiano et al. 2001). The efficacy of STN DBS has proved stable over time and there is a marked improvement in the patients' day to day living (Krack et al. 2003; Kleiner-Fisman et al. 2003).

The effect of electrical stimulation on gait has been assessed by a clinical 0–4 rating (item 29, Unified Parkinson's Disease Rating Scale – UPDRS, part III) and the walking test (Defer et al. 1999). Both suggest a normalization of the main gait parkinsonian features (Yokoyama et al. 1999; Bejjani et al. 2000) but are inadequate for a quantitative analysis of gait character-