ANALYSIS OF POSTURAL CONTROL IN PARKINSON’S DISEASE

C. Re¹³, L. Baratto¹², P. Morasso¹², G. Spada¹
¹Bioengineering Centre - ²Motor Rehabilitation Dept.; Hospital La Colletta – ASL 3, Arenzano, Italy
³University of Genova, Dept. of Informatics, Systems, Telecommunications, Genova, Italy

INTRODUCTION

The evaluation of the degree of impairment of Parkinsonian patient is normally based on symptomatic evaluation scale, such as UPDRS, which are only qualitative and lack quantitative precision. However, it is very difficult to prepare a proper scale for Parkinson’s disease (PD) always suitable and quickly executable in relation to the variety of symptom of this disease. Many scales are applied only to single settings, for example to daily activities or to motor or psychic impairment related to PD. The symptoms shown by the patient with PD are different depending on static or dynamic situation. Investigation of corrective responses to small and brief perturbations of upright standing (for instance force pulses applied to the sternum) might contribute to unveil the mechanisms underlying the neural control of posture. The contributions of the motor components can be divided into 3 classes: (1) muscular, (2) reflex and (3) anticipatory. Manoeuvres based on force pulses (i.e. pushes) applied to the sternum are often used clinically: in fact, they are part of a popular test of functionality of postural control, as in Tinetti’s performance test. One of the long-term goals of our researches is to understand the spinal and supraspinal mechanisms that mediate the control of standing posture, and how they change under pathological conditions (spasticity, Parkinsonian rigidity, ageing, etc), by the use of electromyographic and posturographic responses. In the context of the present paper, we investigated the interaction among the various compensatory mechanisms activated in response to perturbations of standing posture (expected or unexpected, with and without vision): central, reflex and intrinsic (i.e., due to muscle mechanical properties) based on posturographic and electromyographic data.

METHODS

Experimental measurements were made with posturography (PG) (static and dynamic) and surface electromyography (EMG): we selected 8 normal subjects and 8 patients with Parkinson’s disease, where normal subject were aged between 26-34, mean 31.8 and Parkinsonian subject were aged between 63-77, mean 69.7; young well trained subject were selected for the comparison because of the high muscle stiffness phenomena in Parkinson disease. The acquisitions were performed in two phases, always with EMG. In the first we collected only static posturography subsequently analysed in three ways: standard posturographic parameters, Collins & De Luca parameters, sway density parameters. In the second we acquired only dynamic posturography with 3 pushes given after the 20th second. The standard Romberg test was used. The subjects were asked to stand quiet on the force platform with their arms relaxed on the side of the body, in two conditions: OE (open eyes, looking at a visual target adjusted at the height of the eyes at a distance of about 1m) and CE (closed eyes). They stood barefoot on the platform with their feet abducted at 20° and heels separated by 2 cm. The measurement of the COP trajectory was carried out for 40 s. The subject was then asked to shut eyes and another measurement was carried out. With EMG we acquired these muscle: anterior tibial m., medial twin m., soleum, and femoral rectum. The COP coordinates and EMG signals were acquired with the same machine synchronously and sampled at 2 KHz and low-pass filtered with a 4th order Butterworth filter (cutoff frequency 300 Hz). All the computations were performed in Matlab©. On the patients with PD we collected also data from symptomatic evaluation scale with Hoehn - Yahr and UPDRS test.

RESULTS AND DISCUSSION

The first approach we used for analysing these data was given by observing EMG muscle activities in Parkinson toward normal subjects. There are great differences between normal subjects, in which muscles activities of the front part of the leg increased highly under pushes condition in the anterior part despite of a relaxation of the back site of the leg.

Main differences are correlated to these phenomena and can be evicted by these parameters:
The EMG power ratio analysis between push and rest interval is greater in Normal subject than in Parkinsonian due to an excess of stiffness of leg muscles also during rest interval in the Parkinsonian subjects.

Observing the data (time course of the AP component of the COP) it is possible to see that in the Parkinsonians the postural response to the push has a significatively longer reaction time, smaller amplitude, and an "uncertain" shape.

Figure 1 shows that the muscle response to the postural disturbance is characterised by a "cog-wheel pattern" that replicates several times the response burst and induces a kind of abnormal rigidity.

From preliminary observations we have recognised Parkinsonian subjects trend to fall backwards. It’s still open to discussion if this trend is to be attributed to excess of activation in the posterior part of leg muscles or if it is caused by an abnormal response of anterior tibial muscle response.

![Figure 1. EMG of different muscles in a Normal Subject (left panel) and a Parkinsonian Subject (right panel); in both panels the right part is a zoom of the strip on the left, centred around the time of push. Muscles: TA= anterior tibial; MG= medial twin; S= soleum; FR= femoral rectum; MLO, APO= medio-lateral and antero-posterior oscillation of the COP; PI= push intensity.](image)

The EMG correlated with posturographic data gives an objective analysis to a precise symptomatic evaluation of the disease and how movement control strategies change in patients with PD depending on the symptoms events. Moreover we have observed that in many patients affected by PD there are deficits in feedforward motor control programming and the contribution of cogwheel rigidity in motor dynamic response and the effect of rest tremor in static conditions.
CONCLUSION
The parameters described above allow to begin the investigation in the behavioural pattern and underline evaluations that cannot be detected from the clinical analysis. The results, which are of some interest for fundamental research in motor control, are particularly relevant in clinical applications, for example in the treatment of age-related balance disorders.

The aim of this study is to investigate the possibility of identifying cog-wheel rigidity and rest tremor effects, which require EMG analysis, with a simpler technique: posturographic analysis. In the future we shall focus on the problem on understanding if the excess of stiffness of the ankle joint during upright standing is triggered by the irregular bursting activity of the posterior part of leg muscles (compensated by a suitable activity of the tibialis anterior m.) or vice versa.

REFERENCES