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Parkinsonian action tremor: Interference with object manipulation and lacking levodopa response

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Abstract

It has been postulated that Parkinsonian action tremor is distinct from classical resting tremor and that it may contribute to a loss of manual dexterity in Parkinson's disease.

We analyzed pinch grip coordination in 20 patients with Parkinson's disease. An object with and without an additional 500 g weight was grasped, lifted and held for a short time with opposed thumb and index finger. Force sensors recorded the force exerted by both fingers. Spectral analysis of the force traces was performed. Transition times between grasping and lifting the object were measured. 18 age matched normal volunteers served as a control group.

While holding the object, there were force oscillations in the 3.5–6.5 Hz band indicating (reemerging) classical Parkinsonian tremor in 65% of the patients. This was reduced to 15–20% under levodopa. Oscillations in the 6–15 Hz band were found in 30% (50% with weight) of the patients, remaining unchanged under levodopa, and in 10% (20% with weight) of the normal controls. During lift initiation, 6–15 Hz oscillations were found in all patients and the majority of controls. The band power was positively correlated with the movement transition times in the severely akinetic patients and was significantly higher than in controls. It remained unchanged under levodopa.

Our data confirm that Parkinsonian action tremor activated during complex voluntary movements is distinct from classical resting tremor. It does not show a clear levodopa response but affects dextrous movement coordination when associated with clinically severe overall akinesia.

Keywords: Parkinson's disease; Rest tremor; Action tremor; Bradykinesia; Manual dexterity; Precision grip

Introduction

While an isolated resting tremor has hardly any effect on the execution of voluntary movements, action tremor may interfere with dextrous movements and can therefore be a source of significant disability. Both types of tremors can be typically observed in Parkinson's disease. The well known low frequency classical resting tremor often reemerges under postural conditions (Deuschl et al., 1998; Jankovic et al., 1999). The action tremor mainly occurs at higher frequencies (Deuschl et al., 1998; Findley et al., 1981). On the one hand, such a higher frequency action tremor is often seen in patients who exhibit the classical low frequency tremor under resting conditions and it may therefore only be a frequency modulation of the oscillations at rest. There are a number of studies that seem to support this view as they report a correlation between higher frequency postural and classical resting tremor and a similar response to levodopa (Henderson et al., 1994; Kulisevsky et al., 1995; Louis et al., 2001). On the other hand, there are some patients with Parkinson's disease who do not show any low frequency resting but only higher frequency action tremor (Deuschl et al., 1998) rather indicating separate mechanisms. This view is supported by a clinical and accelerometric study (Zimmermann et al., 1994) that looked at rest, postural and kinetic tremor in PD demonstrating that postural tremor in PD either appears as reemergent tremor being well correlated with the low frequency classical resting tremor or as an independent second tremor which is maintained during voluntary move-

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ments. Recently, it has been shown in quantitative studies that this higher frequency tremor is activated during natural multijoint finger and hand movements even in patients who show the classical low frequency reemergent postural tremor (Forssberg et al., 2000; Wenzelburger et al., 2000). It has been postulated that this tremor may be an exaggeration of the central component of physiological tremor as it falls within the same frequency range (Forssberg et al., 2000; Wenzelburger et al., 2000) and that it may contribute to the loss of manual dexterity in PD (Gordon et al., 1997; Forssberg et al., 2000; Ingvarsson et al., 1997). As physiologic tremor is independent of a dopaminergic deficit, it should not improve under levodopa to the same extent as the classical Parkinsonian resting tremor, and if the higher frequency action tremor really impairs the accuracy of fine manual movements, one would expect a correlation between tremor strength and the kinematics of manual motor performance. We tested for these hypotheses in the present study by analyzing the grip force coordination and the superimposed tremor during different phases of object manipulation (Johansson and Westling, 1984; Forssberg et al., 2000; Wenzelburger et al., 2002) in patients with Parkinson's disease.

Methods

Patients and subjects

We recruited 20 patients with idiopathic Parkinson's disease (mean age 61 ± 8 years). All of the patients fulfilled the UK brain bank diagnostic criteria (Hughes et al., 1992). Patients were selected on the basis of our laboratory data base to cover a broad range of overall disease severity (Hoehn and Yahr stages 1.5–5, Total Motor score (UPDRS III): OFF: 11–58, ON: 3.5–41) and a broad range of tremor severity. Approximately half of the patients had no or only weak (UPDRS rest-tremor score < = 1) classical Parkinsonian rest tremor while rest-tremor scores went up to 4 in the other half. Before the recordings, patients were asked to omit their late evening and morning medication. Thus, they were in an OFF state when they arrived for the tests in the morning. The set of clinical (UPDRS III) and physiological tests was performed once in this situation and repeated after the intake of a single dose of 200 mg of levodopa. The clinical characteristics of the patients at the time of the tests are given in Table 1.

The only exclusion criterion was strong levodopa-induced dyskinesias that yielded the tremor measurements uninterpretable due to superimposed involuntary movements unrelated to tremor.

As a control group, 18 age matched normal volunteers (mean age: 58.4 ± 9 years) were recruited from hospital staff and their relatives. All of these subjects were examined by a neurologist and only those without any neurological abnormalities were included in the study. Further exclusion criteria were a history or family history of tremor or Parkinsonian syndromes and intake of centrally acting drugs. All subjects were asked to refrain from caffeine consumption for at least 2 h prior to the tests.

Table 1

Pat.	Age (years), sex	Disease duration (years)	H & Y OFF/ON	UPDRS III				
				Total OFF/ON	*Rest tremor* more affected arm OFF/ON	*Action tremor* more affected arm OFF/ON	*Rigidity* more affected arm OFF/ON	*Akinesia*[a] more affected arm OFF/ON
1	65.5, M	12.9	5/4	42/29.5	0/0	0.5/0.5	2.5/1.5	6/3.5
2	56.8, M	18.0	4/2.5	38/23	1/0	1/0	1.5/1	6.5/4
3	55.0, M	18.0	4/3.5	50.5/30.5	2/0	1/1	2/1	8/4
4	60.9, M	5.0	1.5/1	11/3.5	0.5/0	1.5/1	2/1	2.5/1
5	60.8, M	7.0	2.5/2.5	25.5/15.5	0/0	1/0.5	1.5/0.5	4/2
6	39.3, M	3.0	2/2	25/11	3/1.5	2.5/1	2/1	5/2.5
7	51.3, M	7.1	2/2	38/20	4/2.5	3/2.5	1/0	3/1.5
8	58.5, F	17.2	3/3	35.5/27	0/0	0.5/0.5	1.5/1	6.5/6
9	80.2, F	14.1	5/4	57.5/41	1/0	1.5/0.5	3/1.5	8/7
10	70.6, F	21.2	4/2.5	45.5/23.5	2/0	1/0	1.5/0	6/2.5
11	69.0, M	4.8	3/2.5	28.5/14.5	1/0	0.5/0	1.5/0.5	6/4.5
12	60.0, M	15.2	2.5/0	35.5/12.5	1/0	1/0	2.5/1	4.5/1
13	65.7, F	8.2	2/1	16.5/7	0.5/0	1/0	1/0.5	4.5/2.5
14	63.8, M	7.2	2.5/2	18.5/8	2.5/0	2.5/1	1.5/0.5	3/1
15	60.8, M	4.2	2/1.5	21.5/14	0.5/0	0.5/0.5	2/1	4.5/2.5
16	64.2, M	8.2	2/2	15.5/9	2/0.5	1/0.5	2/1.5	2/1
17	63.7, F	30.3	4/2.5	66/36	2/2	0/0	3/1	10/6
18	51.9, M	6.3	2/1	16.5/6	3/2	2/0	1/1	1/0
19	63.4, F	13.3	2/1.5	23/11.5	3/3	0/0	1/0	6/2
20	60.7, M	7.3	3/2.5	41.5/18	0/0	0/0	1/0	5.5/0

[a] Compound akinesia score adding up all three hand/arm akinesia items (items 23–25 of UPDRS III).