off–OFF dyskinesias was considered, given the relatively high daily dose of L-dopa he was taking (1,200 mg/day). The long duration effect has not been associated with dyskinesia, however, and the subject never had dyskinesia noted overnight at any other time while he was taking L-dopa.

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LEGENDS TO THE VIDEO

Segment 1. The subject at the 1-month postoperative evaluation, off medications overnight and with DBS stimulators on, demonstrates moderate Parkinsonism without dyskinesia.

Segment 2. The subject at the same 1-month postoperative evaluation off medications overnight, approximately 2 minutes after turning off the DBS stimulators, demonstrates choreiform dyskinesia primarily of the facial muscles, neck, and legs and dystonic dyskinesia of the left arm, along with increased mobility.

Segment 3. The subject at the 6-month postoperative evaluation, off medications overnight and with DBS stimulators on, demonstrates modest Parkinsonism that is improved compared to his 1-month postoperative evaluation and no dyskinesia.

Segment 4. The subject at the 6-month postoperative evaluation off medications overnight, approximately 2 minutes after turning off the DBS stimulators, demonstrates choreiform dyskinesia primarily of the facial muscles, neck, and legs, along with increased mobility.

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“Paradoxical Kinesis” Is not a Hallmark of Parkinson’s Disease but a General Property of the Motor System

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Abstract: Although slowness of movement is a typical feature of Parkinson’s disease (PD), it has been suggested that severely disabled patients remained able to produce normal motor responses in the context of urgent or externally driven situations. To investigate this phenomenon (often

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designated “paradoxical kinesis”), we required PD patients and healthy subjects to press a large switch under three main conditions: Self Generated, produce the fastest possible movement; External Cue, same as Self Generated but in response to an acoustic cue; Urgent External Cue, same as External Cue with the switch controlling an electromagnet that prevented a ball falling at the bottom of a tilted ramp. Task difficulty was equalized for the two experimental groups. Results showed that external cues and urgent conditions decreased movement duration (Urgent External Cue < External Cue < Self Generated) and reaction time (Urgent External Cue < External Cue). The amount of reduction was identical in PD patients and healthy subjects. These observations show that paradoxical kineses are not a hallmark of PD or a byproduct of basal ganglia dysfunctions, but a general property of the motor system. © 2006 Movement Disorder Society

Key words: Parkinson disease; stress; self-initiated movement; reaction time; movement time; reaching

Although slowness of movement is a typical feature of Parkinson’s disease (PD), it has been suggested that severely disabled patients remained able to produce normal motor responses under particular circumstances. For instance, we have all heard the stories of these wheelchair-confined patients who, upon hearing someone shout “fire” in a building, run out as rapidly as all the other nonparkinsonian occupants, only to “freeze” again once in a safe area.1,2 During the past decades, such anecdotal reports of normal motor behavior in PD patients have been echoed by more controlled experimental findings. It was shown, in particular, that PD patients: (1) display bradykinesia when performing maximal speed reaches to a stationary ball, but not when reaching for a moving ball3; (2) exhibit a restored gait pattern when dynamic sensory cues are available during walking4–6; (3) perform sequential arm movements significantly faster in the presence of external temporal cues.7,8 To account for these effects, originally called “kinesia paradoxica” by Souques,1 it was claimed that the basal ganglia (BG) network plays a much more essential role in internally than in externally regulated actions.9–13 Direct support to this idea was provided by functional imaging studies showing activation within the BG network for self-initiated but not for externally driven movements.13–15 Such specificity, however, only was observed when the different movements types were compared to a rest condition. No higher activation in the BG network was observed when the self-initiated and externally driven movements were compared with each other.13–15 An absence of systematic involvement of the BG for internally regulated movements was also reported in electrophysiological and inactivation studies in monkeys.16–19

A possible way to resolve the controversies above would be to determine whether paradoxical kineses are specific to PD (or at least more dramatic in PD). To date, this question has not been directly addressed. It is true that previous studies have used control groups. However, in these studies, identical tasks were used for the control and the patients, which means that the self-determined maximal speed of the healthy subjects was never really challenged.3,6–8 For instance, in a recent experiment by Majsak and colleagues3 both the normal subjects and the PD patients were instructed to grasp a ball that was either (1) fixed stationary in the center of a designated contact zone, or (2) rolling from left to right on a tilted ramp. Results indicated that PD patients were slower in the first than in the second condition. No difference was observed for the control subjects. The incline of the ramp, however, was the same in the patients and controls and, as noted by Majsak and colleagues,3 “although a ball velocity was used that challenged the maximal reaching speed of Parkinson’s disease subjects, it may not have forced healthy subjects to move at their own maximal reaching speed (p 762).” The main aim of the present study is to address this reservation. To this end, we investigated a ball-catch paradigm and used an error criterion (percentage of catches) to equalize task difficulty across subjects and groups.

SUBJECTS AND METHODS

There were 6 bilateral parkinsonian patients (Table 1) and 8 healthy subjects (7 men, 1 woman; mean age, 46 ± 10) who participated in the study after their informed consent was obtained. All subjects were right-handed. Parkinson’s disease patients fulfilled the UK Parkinson’s Disease Brain Bank criteria for idiopathic Parkinson’s disease.20 The patients did not exhibit major signs of tremor. At the time of evaluation, they had been off medication for more than 12 consecutive hours.

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F, female; M, male; H & Y, Hoehn and Yahr; L-dopa equivalent, 100 mg L-dopa = 10 mg Bromocriptine = 5 mg Ropinirole = 1 mg pergolide = 50 mg Piribedil.
Participants were seated comfortably in front of the experimental apparatus (Fig. 1). Their right hand was positioned on a touch-sensitive horizontal surface 30 cm away from a large vertical contact plate (28 × 18 cm). Contact with this plate controlled an electromagnetic catch located at the bottom of a tilted ramp. Subjects were instructed to maintain gaze fixation on a bright red dot positioned in front of the electromagnetic catch. Two types of conditions were considered. (1) Internally driven (or Self-Initiated). The subjects were required to “wait until they felt ready and then hit the push button with the fastest possible movement.” (2) Externally driven. Three subconditions were considered: Beep-Alone, the subjects were required to “react and move as fast as possible in response to an auditory cue”; and Beep-Ball, this condition was identical to the Beep-Alone condition, except that the auditory cue sounded as a ball was released at the top of the ramp (neither the ball nor the release mechanism were visible). The subject was asked to stop this ball with the electromagnetic catch. Failure to touch the contact plate quickly enough resulted in the ball dropping to the floor. Ramp tilt was adjusted for each subject before the experiment during a short training session so as to ensure a failure rate roughly equal to 50%. The Beep-Ball-Vision condition was identical to the previous condition except that vision of the rolling ball was allowed. This condition was added to test whether the visual flow could play a critical role in the occurrence of paradoxical kineses. This role is plausible considering, for instance, that rapid motion signals (>6 deg/sec) can reach area MT by means of a specific “fast route” that bypasses the primary visual cortex. A role of the visual flow for paradoxical kineses has also been suggested in the context of gait control. After completion of the trial, the subjects had to bring their hand back to the starting point. The size of this starting point (microswitch) was small (10 × 5 mm), and the subjects had to perform this task under visual guidance. This strategy prevented the occurrence of regular rhythmic movements in the self-generated condition. The different conditions were presented in separate blocks of 25 trials. Blocks were randomly ordered within an experimental session. Subjects were informed of the trial type at the beginning of each new block. Two sessions were performed for each subject. The experimental instruction was frequently repeated to the subjects to ensure a consistent focus on rapid responses. The instructions were repeated most often under Internally Driven and Beep-Alone conditions.

Movement duration (MD, interval from start position release to contact with the vertical plate) was computed for all conditions. Reaction time (RT, interval from beep to start position release) was only computed for the externally triggered conditions (RT has no meaning in for the self-generated movements). A between-group (PD, Control) by within-condition (experimental, condition) analysis of variance (ANOVA) design was used to identify significant differences between the experimental groups and conditions. Data from all responses were incorporated in this ANOVA, including responses that failed to stop the ball. When the subject anticipated the external cue, the trial was canceled and presented again. It may be worth noting that the number of anticipation errors was both small and identical in both groups (PD, 1.6%; Controls, 1.7%; F(1,12) = 0.04; P = 0.85). It was also identical across the different experimental conditions (F(3,36) = 0.04; P = 0.99). The Duncan’s multiple range test was used for post hoc comparisons of the means. The threshold for statistical significance was set at 0.05.

RESULTS

For MD, significant effects of the group (F1,12 = 18.0; P < 0.002) and condition (F3,36 = 12.9; P < 0.0001) factors were found, without interaction (F2,24 = 0.35; P > 0.75). The group effect indicated that MD was longer in the PD patients than in the healthy subjects (172 ± 38 msec vs. 112 ± 23 msec). The condition effect revealed four important results (Fig. 2A): (1) MD was longer in the self-generated condition (161 msec) than in the externally driven conditions (136 msec; post hoc; all P < 0.003); (2) MD was longer in the beep-alone (143 msec) than in the beep-ball condition (131 msec; post hoc; P < 0.003); (3) MD was the same in the beep-ball trials whether or not vision of the rolling ball was allowed (131 msec vs. 132 msec; post hoc; P > 0.80). As shown by the absence of a group by condition interaction, these effects were similar in the patients and healthy subjects. With respect to this point, it is worth mentioning that the behavior of the subjects was very
consistent across the experimental conditions. As shown in Figure 2B, all the subjects except 2 (1 PD, 1 control) exhibited longer MD in the self-generated than in the beep-alone condition (the same result was obtained when the self-generated condition was compared with the beep-ball condition). Likewise, all the subjects except 3 (3 controls) exhibited longer MD in the beep-alone than in the beep-ball condition (Fig. 2C).

Although RT (delay between the positioning of the hand on the starting point and movement onset) has no meaning in the context of the self-generated movements, it was computed for this condition. Results indicated that RT was very variable from trial to trial (PD, mean intraindividual SD = 420 msec; Controls, 414 msec). This observation shows that the subjects did not perform the self-generated movements as regular rhythmical movements. This result is illustrated in Figure 3C.

For the three externally driven experimental conditions, RT showed the same pattern of variation as MD (see Fig. 3A). Indeed, for RT, a significant effect of the condition factor was observed ($F_{2,24} = 17.9; P < 0.0001$), with no condition by group interaction ($F_{2,24} = 0.16; P < 0.85$). As shown by post hoc analyses, RT was longer in the beep-alone condition (276 msec) than in the beep-ball (243 msec; $P < 0.0005$) and beep-ball-vision (230 msec; $P < 0.0001$) conditions. The two latter conditions did not differ significantly ($P > 0.10$). As already emphasized for MD, the absence of a group by condition interaction indicated that the effect of the condition factor was similar in the patients and healthy subjects. As already observed for MD, the effect of the experimental conditions, in fact, was very consistent from subject to subject. As shown in Figure 3B, only 2 subjects (2 controls) showed higher RT in the beep-alone than in the beep-ball (the same result was obtained with the beep-ball-vision condition).

**DISCUSSION**

There are three main results in the present study. First, PD patients can exceed their self-determined maximal movement speed of reaching in the context of externally driven conditions (Self-Generated vs. Beep-Alone). This result confirms previous observations by Majsak and colleagues. Second, PD patients can exceed their externally driven maximal response speed (RT and MD) in the context of urgent situations (Beep-Alone vs. Beep-
Ball). Third, PD patients are slower than control subjects for all experimental conditions. More precisely, we found the sensitivity to movement context to be quantitatively similar in the patient group and the healthy population when task difficulty was controlled. Stated differently, this result indicates that the behavioral effects reported in the first two results are not specific to PD. They are also present in healthy subjects. This finding suggests that contextual variations of the movement velocity are independent of BG dysfunctions. As emphasized in the introduction, one may argue that a failure to balance task difficulty prevented identification of this independence in previous studies.

When considered together, the above results contradict the belief that movements based on internal cues are particularly impaired when BG are lesioned. Because this belief is widely accepted, its lack of really decisive experimental support seems worth emphasizing. At a first level, the results of the present experiment suggest that the greater PD-related slowing reported in previous studies in the context of self-initiated response was associated with a failure to balance task difficulty in the PD and control groups. At a second level, it is true that imaging studies have identified metabolic activations within the BG network for self-initiated but not for externally driven movements. However, the idea that the BG would not contribute to the execution of externally driven movements is unlikely (for a discussion see Mink). Also, imaging studies have failed to identify significant activation of the BG network when self-generated and externally driven responses were directly contrasted. In agreement with this observation, electrophysiological experiments have not been successful at revealing a preference for internally triggered movements in the BG network. With respect to this point, it is plausible that the preference for internally triggered movements reported for BG-recipient thalamic territories (SMA inputs, in particular; see Rouiller and colleagues).

Before bringing this discussion to an end, it may be worth mentioning that the present study does not provide direct information regarding the mechanisms that cause the PD patients and the control subjects to exhibit faster responses in the context of externally driven or urgent situations. However, an appealing hypothesis might be formulated under the assumption that human movements follow optimal control principles (for a review, see Todorov). According to these principles, movement kinematics are determined so as to optimize the use of neuromuscular energy. The amount of energy allotted to the task results from a trade-off between the motivation underlying the action and the necessity to repeat this (or other) action throughout the day. When the constraints of the task become more stringent, the system is forced to adopt a more “expensive” trade-off. In other words, in the presence of external cues or in temporally pressuring contexts, the goal can only be achieved if more energy is expended. According to this view, whereas PD patients cannot allocate as much energy, i.e., produce as much force, as control subjects to achieve a given task, they remain able to modulate the level of energy expenditure according to the demands of the task. This model is consistent with our data, many observations of the literature, and the claim of at least 2 of our PD patients who spontaneously reported that the externally driven–urgent condition was particularly “tiring” for them.

In summary, although PD leads to a systematic slowing in motor performance, both PD patients and healthy subjects are able to overcome their self-determined maximal speed in the context of externally driven and temporally pressing conditions. This finding suggests that paradoxical kineses are not a byproduct of BG dysfunctions but a general property of the motor system.

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Cervical Dystonia Responsive to Acoustic and Galvanic Vestibular Stimulation

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Abstract: We examined the effects of acoustic and galvanic vestibular stimulation in a patient with cervical dystonia. Acoustic stimulation consisted of three conditions: “baseline” (no stimulation), “vestibular” (500 Hz bone-conducted tone bursts), and “control” (5,000 Hz tone bursts). Rectified electromyographic activity in the sternocleidomastoid was measured. Galvanic stimulation (1.5–2.5 mA current steps) was delivered to the mastoids, and head acceleration was measured. Vestibular acoustic stimulation reduced neck muscle activity between 16% and 44% (P < 0.001), and galvanic stimulation reduced head acceleration by 22.5% (P = 0.028). The patient reported subjective improvement in head control. Vestibular stimulation can reduce neck muscle activity in cervical dystonia and give symptomatic relief. © 2006 Movement Disorder Society

Key words: cervical dystonia; vestibular reflexes; VEMP; bone conduction; galvanic

Cervical dystonia is a sustained, involuntary contraction of neck muscles that produces a disabling abnormal head posture.1 Patients with cervical dystonia often have concomitant vestibular abnormalities, such as vestibulococular reflex asymmetries,2 canal pareses,2 a directional preponderance of nystagmus on rotational testing,3,4 and asymmetrical sound-evoked vestibulo-collic reflexes.5 However, it is unclear whether these abnormalities are causative, associative, or compensatory.6 The main treatment for cervical dystonia consists of injection of botulinum toxin into affected neck muscles.

Loud sounds and galvanic currents have been shown to be efficient vestibular stimuli7–9 and can be used to test the integrity of the vestibulo-collic pathway. After an acoustic or galvanic stimulus, a reflex can be recorded in the ipsilateral sternocleidomastoid (SCM) at short latency.10,11 Recent intramuscular recordings have demonstrated that the initial reflex corresponds to an inhibition

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