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KINEMATIC ANALYSIS OF GRASPING IN FOCAL DYSTONIA OF THE FACE AND NECK

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Abstract—The kinematics of hand transport and grasp formation when reaching for and grasping cubes of different sizes were investigated in subjects with blepharospasm, subjects with torticollis and healthy subjects. Patients scaled peak grasp aperture accurately to object size, reflecting accurate sensorimotor integration of the intrinsic object characteristics. Likewise, the timing of peak grasp aperture in relation to the time of hand transport did not differ between patients and controls. In contrast, patients with blepharospasm and torticollis produced longer movement times and smaller peak velocities of hand transport. Increased movement times and slowed hand transport correlated significantly with symptom severity as assessed by the Unified Dystonia Rating Scale. The observation that the processing of peak grasp aperture was unaffected by blepharospasm or torticollis does not support the current concept of impaired sensorimotor integration. The slowing of hand transport appears to reflect a strategic response to compensate for insecurities in the execution of reaching movements to be found in focal dystonia of the face and neck.

Key words: blepharospasm, torticollis, sensorimotor integration, grasping.

INTRODUCTION

Dystonia is a movement disorder characterised by sustained involuntary muscle contractions, frequently causing twisting and abnormal postures (Chen and Hallett, 1998; Fahn, 1998). By definition, focal dystonia affects only one part of the body with symptoms ranging from permanent to occasional (Fahn, 1998; Lim et al., 2001). To date, the pathophysiology of dystonia remains poorly understood. Dystonia is suggested to be related to a dysfunction of the cortical–striatal–thalamic–cortical motor loop (Berardelli et al., 1998). However, the observation that many forms of focal dystonia are associated with ill-defined bodily feelings (i.e. discomfort, pain or kinaesthetic sensations) and that ''sensory tricks'' can be used to ameliorate many forms of focal dystonia (Fahn, 1998; Lim et al., 2001) indicates that somatosensory information processing also plays an essential role in the pathophysiology of the disease (Abbruzzese and Berardelli, 2003). Consequently, the theoretical concept of impaired sensorimotor integration underlying focal dystonia has attracted increasing interest (Chen and Hallett, 1998; Fahn, 1998; Abbruzzese and Berardelli, 2003).

Sensorimotor integration is an integral part of our daily motor repertoire. For example, when we reach to grasp an object in our environment, the brain uses visual and somatosensory cues of intrinsic object properties, such as size and shape, to generate an accurate movement pattern (Jeannerod et al., 1995). The accurate shaping of the fingers is an essential feature to ensure a proper grasp. The fingers begin to shape during the transport of the hand and the process of grasp formation first involves a progressive straightening of the fingers followed by a closure of grasp until it matches object size (Jeannerod et al., 1995; Castiello, 2005). The amplitude of peak grasp aperture is highly correlated with object size and therefore reflects the accuracy of central processing and integration of visual input (Jeannerod et al., 1995; Castiello, 2005). Both hand transport and grasp formation are closely coupled in time, e.g. the point in time when grasp aperture is largest is a clearly identifiable landmark that occurs within 60–75% of completion of hand transport (Castiello, 2005).

If focal dystonia of the face and neck was associated with a general impairment of sensorimotor integration, such impairment should be independent of the body part affected and, accordingly, evident in reach-to-grasp movements. We therefore assessed the kinematics of reach-to-grasp movements in subjects with blepharospasm and torticollis, and related their performance to that of healthy control subjects. In particular, impaired processing of peak grasp aperture should reflect deficient sensorimotor integration given the strong correlation between this measure and the intrinsic object characteristics. The current data may add novel insights into the mechanisms underlying focal dystonia and their impact on motor performance.

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EXPERIMENTAL PROCEDURES

Subjects and clinical measures

Fourteen subjects with focal dystonia of the face or neck participated in the experiments. Patients were recruited among consecutive outpatients with adult onset primary dystonia presenting with blepharospasm without eyelid apraxia or torticollis. Diagnosis was confirmed clinically based on the EFNS guidelines on diagnosis and treatment of primary dystonias (Albanese et al., 2011) and by evaluation of patient files by senior experts in movement disorders. Seven patients (three females, 34–65 years, mean age ± standard deviation = 48 ± 12 years) suffered from torticollis, seven patients (six females, 58–82 years, mean age ± standard deviation = 70 ± 9 years) suffered from blepharospasm without eyelid opening apraxia. Seven healthy subjects (four females, 56–74 years, mean age ± standard deviation = 60 ± 12 years), without evidence of a neurological deficit or an orthopaedic disease, served as control. Informed consent was obtained from each participant prior to participation and the protocol had been approved by the local Ethics committee. All participants had a right hand preference as determined by a handedness questionnaire (Crovitz and Zener, 1965). Patients were investigated no earlier than 3 months following the last injection of botulinum toxin type A. Therefore patients with blepharospasm suffered from dystonic eyelid squeezing and patients with torticollis suffered from dystonic posturing of the head during experimental task performance, which was monitored clinically during the experimental sessions. To assess dystonic symptom severity the Unified Dystonia Rating Scale was assessed for each patient (Comella et al., 2002). Clinical tests of cutaneous (two point discrimination, sensation of light touch, graphaesthesia) and proprioceptive sensitivity (kinaesthesia, vibration sensation, position sense) were normal at both hands in each patient. Patients were excluded from the study if their previous medical history suggested coexistent neurological, medical or orthopaedic illness of the upper extremities or psychiatric illness. For a summary of clinical data of patients see Table 1.

Data recording

Performance of the reach-to-grasp task was monitored using an ultrasonic motion measurement system (CMS 20S, Zebris, Isny, Germany). The system uses three microphones to continuously record the spatial positions of small ultrasound emitting markers (diameter: 5 mm) attached via flexible cables to the moving segments of the upper limb (see Fig. 1). Three position markers were used: one was fixed to the styloid process of the radius to measure the transport movement of the hand, one was placed on the dorsal tip of the index finger and one was attached to the dorsal tip of the thumb. The position markers placed on the dorsal tips of the index finger and thumb allowed the registration of the opening and closure of the grasp. Spatial coordinates of each position marker were sampled at a frequency of 100 Hz and a spatial resolution of 0.1 mm.

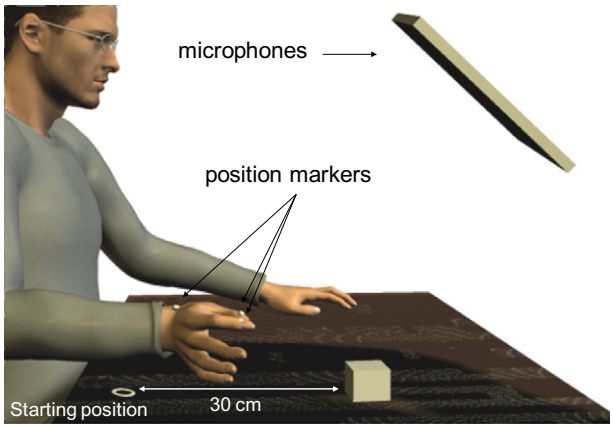

Fig. 1. Experimental set-up for the investigation of reach-to-grasp movements. Hand transport and grasp formation when grasping cubes of different dimensions were investigated by the use of an ultrasound-based kinematic motion analysis system. Small ultrasound emitting position markers were fixed to the tips of the index finger, thumb and styloid process of the wrist. Three microphones allowed the recording of the position signals of each marker in three-dimensional space.

Task procedure

All participants performed the experiments with both hands within one testing session lasting about 20 min. Participants were allowed to break for several minutes whenever they wanted to prevent fatigue. They were seated in a comfortable and stable chair in front of the experimental table. The task was first demonstrated to the participants. A few practice trials were allowed to avoid learning effects and ensure that participants' performance was in accordance with the instructions. Patients and controls started each experiment with the right hand. The experimental set-up is illustrated in Fig. 1. Subjects placed the

Table 1. Clinical details of patients with focal dystonia

Patient	Gender	Age (years)	Hand dominance	Duration of symptoms (years)	Diagnosis	Unified Dystonia Rating Scale
1	F	34	R	17	Torticollis R	3.5
2	M	39	R	4	Torticollis L	5.5
3	F	40	R	6	Torticollis R	3
4	F	43	R	11	Torticollis R	9
5	M	49	R	4	Torticollis R	7.5
6	F	64	R	11	Torticollis L	5
7	F	65	R	9	Torticollis L	6.5
8	F	58	R	0.5	Blepharospasm L	9
9	F	64	R	6	Blepharospasm B	6.5
10	F	66	R	10	Blepharospasm L	3
11	M	66	R	20	Blepharospasm B	8
12	F	70	R	9	Blepharospasm R	3.5
13	F	82	R	10	Blepharospasm L	2.5
14	F	82	R	13	Blepharospasm B	3.5

F = female; M = male; R = right, L = left; B = bilateral; All patients were examined > 3 months after the last botulinum toxin injection.