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Effect of the angle of shoulder flexion on the reach trajectory of children with spastic cerebral palsy

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ABSTRACT

Many children with cerebral palsy (CP) use a wheelchair during activities of daily living and often extend their hand upward and downward to reach objects in a seated position in a wheelchair. However, the effect of shoulder position on reaching movements of children with CP is not established. The purpose of this study was to determine the effect of the angle of shoulder flexion on the reach trajectory of children with spastic CP. Seven children with mild CP [Manual Ability Classification System (MACS) levels I–II], five children with severe CP (MACS levels III–V) and six typically developing (TD) children participated. We prepared the device to have a top board with variable tilting angle in order to reduce the effect of gravity imposing on reaching movements. By using this device, the subjects could extend their arm by sliding it on the board to push a target button. The reaching movements were performed with the more affected hand at three angles (60°, 90° and 120°) of shoulder flexion and captured using a camera motion analysis system. Subjects in the TD and mild CP groups reached the target at 60°, 90° and 120° of shoulder flexion. Subjects of the severe CP group reached the target at 60° and 90° of shoulder flexion, but two of the subjects could not reach the target at 120° of shoulder flexion. The TD and mild CP groups showed smooth and almost straight trajectories at all three angles of shoulder flexion; however, the reach trajectory in the subjects with severe CP changed with the angle of shoulder flexion. A large angle of shoulder flexion induced great outward deviation in the trajectory. These findings suggest that the difficulty of the reaching task is changed depending on the shoulder joint angle in children with severe CP and that therapeutic interventions for children with severe CP should be provided in a manner appropriate for the shoulder joint angle.

1. Introduction

Cerebral palsy (CP) is one of the most common neurologic problems in children referred to physical therapists. Children with CP have impairment of motor function that is due to a non-progressive interference, lesion, or abnormality in the immature brain. About one third of children with CP are non-walking (SoCPiE, 2002) and about 60% of them have problems

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with upper limb function (Arner, Eliasson, Nicklasson, Sommerstein, & Hägglund, 2008). Upper limb function to reach, grasp, transport and release objects is needed for activities of daily living (ADL) such as eating, bathing and grooming. Children with disabilities of upper limb function have reduced their ADL.

Reaching is a necessary behavior for ADL. Many children with CP use a wheelchair during ADL and often extend their hand upward and downward to reach objects from a seated position. However, the effect of shoulder position on reaching movements of children with CP is not established. Some studies have examined shoulder kinematics of reaching movements in children with CP. Children with hemiplegic CP show a reduced range of motion in the shoulder (Coluccini, Maini, Martelloni, Sgandurra, & Cioni, 2007) and reduced shoulder elevation during reaching (Jaspers et al., 2011). These reports suggest that reaching movements of the children with CP are changed depending on the angle of shoulder flexion. Our clinical impression is that the reach trajectory of children with severe CP would show deviation depending on the angle of the shoulder flexion.

The purpose of this study was to determine the effect of the angle of shoulder flexion on the reach trajectory of children with spastic CP.

2. Methods

2.1. Subjects

Following approval from the Ethics Committee of Kyoto University Hospital and Graduate School of Medicine (E1072), twelve children with spastic CP and six typically developing (TD) children participated in this study. Informed consent was obtained from children and parents prior to participation. The children with spastic CP had sensorimotor impairments in at least one arm, were able to hold a sitting position, and had cognitive skills sufficient to understand instructions. Children with severe cognitive deficits that precluded performance of the task, or severe range of motion impairment of the shoulder and elbow were excluded. Children with CP were classified into two groups using the Manual Ability Classification System (MACS) (Eliasson et al., 2006): a mild CP group ($n = 7$) (MACS levels I–II) in which the children were able to handle objects by themselves, and a severe CP group ($n = 5$) (MACS levels III–V) in which the children required some assistance to handle objects (Table 1).

2.2. Device and task

In order to reduce the effect of gravity imposing on reaching movements, we prepared the device having a top board with variable tilting angle (Fig. 1A). The subject was seated in a semicircular cutout section of the board with the reaching arm relaxed on the board. The top board height was adjusted so that the top plate was at the subject's armpit height, and the angle of the top board was set at 60°, 90° and 120° of the shoulder flexion (Fig. 1B). The subjects were able to extend their arm by sliding it on the board. The subject's trunk was fixed in the semicircular cutout section of the board to prevent rotation, and if necessary, we supported the trunk from the rear.

The target button (15 cm in diameter) was placed on the board directly in front of the midline of the subject at the arm's-length distance that was defined as the distance from the medial axillary border to the crease of the extended elbow. The subject's hand was placed at the start position that was near the subject and aligned with the sagittal midline of the trunk at the beginning of each trial. The subjects were instructed to reach and push the target button. Reaching movements were

Table 1
Characteristics of the subjects in the study.

Subject ID	Gender	Age	Height (cm)	Weight (kg)	MACS	Impairment distribution	Preferred Hand
Severe CP group							
S01	F	13	116.5	17.2	III	Quadriplegia	Right
S02	M	15	137.5	26.8	V	Quadriplegia	Right
S04	F	17	138.3	48.4	IV	Hemiplegia	Left
S05	M	17	157.4	42.0	IV	Quadriplegia	Right
S09	M	10	123.0	24.1	IV	Quadriplegia	Left
Mean	2F/3M	14.4 ± 3.0	134.5 ± 15.8	31.7 ± 13.0			2left/3right
Mild CP group							
S03	F	18	144.5	35.7	II	Quadriplegia	Left
S06	M	16	142.0	38.2	II	Quadriplegia	Left
S07	F	15	158.1	42.5	II	Quadriplegia	Right
S08	M	18	172.5	57.9	I	Diplegia	Right
S10	F	8	127.3	23.9	II	Quadriplegia	Right
S11	M	15	153.7	33.8	II	Diplegia	Right
S12	M	17	155.0	53.6	I	Diplegia	Right
Mean	3F/4M	15.3 ± 3.5	150.4 ± 14.3	40.8 ± 11.7			2left/5right
TD group							
Mean	6F	9.2 ± 1.9	139.0 ± 5.9	31.5 ± 5.3			1left/5right

MACS, Manual Ability Classification System.