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Three-dimensional analysis of performance of an upper limb functional task among adults with dyskinetic cerebral palsy

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ABSTRACT

Patients with dyskinetic cerebral palsy (DCP) experience considerable variability in their purposeful movements due to involuntary movements that contribute to functional impairment. Movement analyses can demonstrate how the movements involved in bringing a mug to the mouth are performed by patients with DCP. Sixteen adults with DCP (29.63 ± 4.42 years) and eleven healthy adults (24.09 ± 3.73 years) performed six consecutive movements of bringing a mug to the mouth using their dominant arm. The mug was placed at 75% of each subject's maximum reach. Kinematic data were captured by 10 cameras and processed using biomechanical software. Fifteen reflexive markers were placed on predetermined bony landmarks on the head, trunk and upper limbs. DCP adults required more time to perform the going (bringing the mug to the mouth), adjusting (simulating taking a drink) and returning (lowering the mug back to the table) phases, and their movements were less smooth than the controls, as indicated by the index of curvature, average jerk and number of movement units. The DCP adults took a longer time to complete the task than controls as indicated by the peak velocities, mean velocities and times to peak velocity. With respect to the angular parameters, DCP adults had a smaller range of motion for shoulder and elbow flexion and forearm pronation compared with the controls. The analysis of functional tasks represents an important measure for the evaluation of dyskinetic movements and permits the quantitative characterization of upper limb impairment in adults with DCP.

1. Introduction

Dyskinetic cerebral palsy (DCP) is one of the most debilitating forms of CP because it causes severe motor impairment [1]. In patients with this disease, primitive reflex patterns predominate, muscle tone varies and recurring, uncontrolled, involuntary, and occasionally stereotyped movements appear [2]. However, there are few studies investigating the functional impairment of the upper limbs associated with DCP. Approximately 50% of this population has impaired shoulder or hand function [3].

Patients with DCP experience abnormal muscle activity stemming from the simultaneous, sustained contraction of the agonist and antagonist muscles during movement [4], resulting in difficulties maintaining spatiotemporal trajectories and considerable variability in their movements [5]. The most common manifestations are dystonia, chorea, and athetosis [6]. These involuntary movements can cause discomfort, interfere with voluntary movements, and limit or even impede upper limb function. Impairments in reaching, grasping and handling make daily activities such as dressing, eating, and maintaining personal hygiene difficult [7].

The lack of studies aimed at analysing movements in patients with DCP poses an obstacle to understanding the motor defects in their upper limbs. Coluccini et al. [4] studied the movements of reaching, grasping, and releasing objects in three children with

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DCP, and only Butler et al. [8] have analyzed the spatiotemporal variables involved in raising a cup to the mouth in their study of 12 children, including seven with DCP.

Such analyses have demonstrated how functional activities, such as the movements involved in raising a glass to one's mouth are performed by other types of patients with impaired upper limb function [12]. However, the few studies on the impaired movement associated with DCP conducted to date have only analyzed upper limb movement in children [4,8], despite the fact that deficits in childhood persist into adulthood and are aggravated by age [9,10].

The involuntary movements and spasticity that may accompany DCP lead to substantial changes in movement and contribute to functional impairment [2]. Analysing movement biomechanics in patients with DCP is fundamental to gaining a better understanding of these movements and establishing therapeutic interventions to inhibit undesirable movements and improve functional performance [11]. Such analyses have demonstrated how functional activities, such as the movements involved in raising a glass to one's mouth are performed by patients with impaired upper limb function [12].

Raising a glass to one's mouth involves the majority of joints in the upper limb and is a challenging but reproducible task for DCP patients. This activity also reveals motor deficits and allows a quantitative assessment of the effect of therapy [13]. The aim of the present study was to analyze the performance of adults with DCP during the task of raising mugs to their mouths through three-dimensional angular and spatiotemporal kinematics.

2. Methods

This study received approval from the local human research ethics committee under No. 429632/2011.

2.1. Volunteers

Volunteers were recruited from a list of 1166 patients treated at the Cerebral Palsy Clinic in 2009–2011. Patients younger than 18 and those with forms of cerebral palsy other than DCP listed on medical charts were excluded. Fifty-nine remaining patients were preselected and contacted by telephone to verify the eligibility criteria and potential for participation in the study.

DCP adults ($N = 16$, 10 males and six females with a mean age 29.63 ± 4.42 years) were selected through consecutive sampling to form the DCP group (Table 1). The following were the inclusion criteria: adults older than 18 years of either sex, involuntary dyskinetic movements of the upper limbs, capability of understanding simple verbal commands, capability of voluntarily moving the upper limbs during the task, agreement to participate in the study, and signature of a statement granting informed consent. Partition in physical therapy was neither an inclusion or exclusion criterion. The following were the exclusion criteria: joint deformities of the upper limbs; associated rheumatic, orthopedic, or neurological conditions affecting movements; history of bone or tendon correction surgery, or tendon or muscle transfers in the preferred upper limb; history of receiving botulinum toxin in the last six months; visual or hearing impairment and skin lesions at the sites where the markers would be placed.

Age-matched young adults ($N = 11$, nine females and two males with a mean age of 24.09 ± 3.73 years) were selected through verbal invitation at the university to compose the control group. Exclusion criteria for the controls were a history of surgical procedures on the preferred upper limb; uncontrolled health conditions; rheumatic, orthopedic, or neurological disease; visual or hearing impairments; and skin lesions at the sites where the markers would be placed (Table 1).

Table 1
Characteristics of the DCP patients ($N = 16$) and controls ($N = 11$) with group means and 95% confidence interval.

	Age (years)	Gender	Preferred arm	Height (m)	Weight (kg)	BMI	MACS
DCP	29	Male	Left	1.58	50	20	II
DCP	31	Male	Left	1.75	50	16.33	II
DCP	24	Male	Left	1.74	62	20.52	II
DCP	27	Female	Left	1.73	58	19.39	II
DCP	23	Male	Right	1.85	70	20.46	IV
DCP	32	Male	Left	1.53	55	23.5	IV
DCP	29	Female	Left	1.54	42	17.72	II
DCP	25	Male	Right	1.56	65	26.74	IV
DCP	37	Male	Left	1.70	52	17.99	III
DCP	47	Female	Left	1.54	55	23.2	IV
DCP	27	Female	Right	1.40	50	22.51	II
DCP	26	Male	Left	1.75	80	26.14	III
DCP	29	Male	Right	1.65	63	23.16	II
DCP	37	Male	Right	1.68	65	23.04	II
DCP	30	Female	Left	1.50	57	23.55	II
DCP	21	Female	Left	1.65	51	18.55	III
Controls	23	Female	Right	1.70	68	23.78	–
Controls	23	Female	Right	1.53	48	20.51	–
Controls	23	Male	Right	1.65	63	23.16	–
Controls	23	Female	Right	1.74	65	21.52	–
Controls	22	Female	Right	1.59	56	22.22	–
Controls	31	Female	Right	1.71	60	20.54	–
Controls	29	Female	Right	1.73	100	33.44	–
Controls	19	Female	Right	1.53	53	22.64	–
Controls	20	Male	Right	1.80	62	17.28	–
Controls	24	Female	Right	1.67	56	20.14	–
Controls	28	Female	Right	1.70	63	21.79	–
DCP = 16	29.62 (26.21, 33.04)	(6 F/10 M)	(5 R/11 L)	1.63	57.81	21.41	II(9); III(3)
Controls = 11	24.09 (21.58, 26.6)[a]	(9 F/2 M)	(11 R/0 L)	(1.57, 1.69)	(52.82, 62.8)	(19.81, 23.03)	IV(4)
				1.67 (1.61, 1.72)[a]	63.09 (54.0, 72.18)[a]	22.46 (19.74, 25.17)[a]	

DCP, dyskinetic cerebral palsy; F, female; M, male; R, right; L, left; m, meters; kg, kilograms; BMI, body mass index; MACS, manual ability classification system.
[a] Values expressed as the mean (95% confidence interval).