Three-dimensional upper limb movement characteristics in children and youth with dyskinetic cerebral palsy

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Introduction

Dyskinetic cerebral palsy (DCP) is a condition characterized by abnormal postures or movements associated with impaired muscle tone regulation, movement control, and coordination (1). Three-dimensional motion analysis has been frequently used to describe movement patterns in children with spastic CP, but less in children with DCP (2-4). Nevertheless, this could be an important contributor to understanding the complex movement patterns in children with DCP and subsequently, personalisation of treatment management (1).

Research question

1) Are the deviating movement characteristics in participants with DCP expressed in deviating joint angles and trajectory deviations? 2) Do participants with DCP have different speed characteristics during upper limb movements?

Methodology

Nine participants with DCP (mean age 17y 6m, range 11-25y) were included, with four bilateral participants leading to 13 DCP measurements. For comparison, 14 age-matched TD participants were included (mean age 17y2m, range 12-23y). Participants were asked to perform 10 repetitions of three functional tasks: reaching forward (RF), reaching sideways (RS) and reach to grasp vertically (RGV). Seventeen reflective markers were placed over the body in 5 clusters: trunk, scapula, upper arm, forearm and hand. Static and dynamic calibrations were carried out to allow for joint angle calculations. Joint angle at point of task achievement, trajectory deviation, maximum velocity, timing of maximum velocity and movement smoothness were calculated. T-tests were used to assess the differences between TD children and children with DCP.

Results

Participants with DCP showed significantly less elbow extension for all tasks, and significantly less elbow supination in the reach and grasp task. During reaching sideways, participants with DCP showed significantly higher external shoulder rotation, less arm abduction and higher external trunk rotation in comparison with their TD peers. Additionally, participants with DCP showed higher heterolateral trunk flexion during the reach and grasp task. For the spatio-temporal parameters, participants with DCP showed a significantly higher trajectory deviation and significantly lower smoothness and maximal speed during all tasks. For timing of maximum velocity, participants with DCP showed a significantly later peak velocity during the reach forwards task (table 1).

Discussion

The decreased elbow extension during all tasks and the decreased elbow supination during the reach and grasp task agree with previous results in participants with spastic CP (2) and could be the result of the presence of spasticity in participants with DCP. The increased external trunk rotation during reach sideways could be a compensatory movement for the smaller shoulder abduction. Participants

with DCP move less straight, where the presence of involuntary movements contributes to significantly higher trajectory deviations and significantly lower smoothness values for all tasks. Additionally, participants with DCP move slower in comparison with their TD peers, and they reach peak velocity at a later time point during the reach forward task.

References

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Table 1: Mean and standard deviation of joint angles and spatio-temporal parameters for TD participants and participants with DCP

	REACH FORWARDS			REACH AND GRASP VERTICAL			REACH SIDEWAYS		
	TD	DCP	p-value	TD	DCP	p-value	TD	DCP	p-value
JOINT ANGLES AT PTA									
TRUNK FLEXION/EXTENSION	-3.11 (5.59)	-1.14 (11.90)	0.583	-2.94 (5.97)	-1.63 (10.26)	0.687	-1.09 (7.44)	0.37 (9.55)	0.661
TRUNK AXIAL ROTATION	7.11 (4.60)	9.47 (10.85)	0.109	7.97 (4.65)	14.77 (9.64)	0.264	-8.17 (4.68)	-16.93 (11.41)	0.014*
TRUNK LATERAL FLEXION	1.27 (3.94)	-1.64 (5.13)	0.463	0.18 (3.74)	-1.96 (5.88)	0.026*	1.02 (4.56)	1.75 (6.00)	0.724
SCAPULA PRO/RETRACTION	45.15 (9.40)	41.70 (11.88)	0.408	45.56 (8.13)	43.37 (10.19)	0.541	7.73 (12.25)	10.81 (14.31)	0.553
SCAPULA ROTATION	-23.78 (11.23)	-19.62 (17.50)	0.467	-17.14 (10.94)	-12.30 (19.76)	0.259	-23.01 (13.77)	-18.92 (17.13)	0.499
SCAPULA TILTING	-2.76 (8.68)	4.74 (13.93)	0.103	-0.88 (8.55)	4.66 (15.66)	0.273	1.51 (12.34)	4.88 (14.64)	0.522
ABDUCTION/ADDUCTION	92.55 (9.04)	84.33 (9.74)	0.066	90.71 (9.63)	83.38 (10.47)	0.123	8.44 (10.31)	21.44 (16.54)	0.031*
SHOULDER ELEVATION	-84.63 (11.06)	-80.89 (13.63)	0.439	-78.19 (10.71)	-80.00 (13.10)	0.697	-74.86 (11.29)	-69.19 (11.11)	0.201
SHOULDER ROTATION	-42.64 (15.04)	-51.44 (13.47)	0.206	-53.00 (12.78)	-55.96 (46.85)	0.865	-34.85 (12.25)	-50.49 (18.37)	0.031*
ELBOW FLEXION/EXTENSION	14.52 (13.77)	38.89 (17.28)	0.000*	22.039 (13.46)	39.40 (16.58)	0.006*	18.42 (15.56)	36.98 (16.44)	0.006*
ELBOW PRO/SUPINATION	129.94 (20.38)	138.37 (19.96)	0.288	94.45 (19.63)	114.86 (26.34)	0.030*	123.74 (21.98)	134.53 (22.96)	0.224
WRIST FLEXION/EXTENSION	12.02 (4.44)	19.41 (19.66)	0.182	-14.57 (14.69)	-8.48 (27.13)	0.470	12.16 (5.93)	22.10 (23.72)	0.141
WRIST DEVIATION	4.85 (7.03)	1.22 (16.40)	0.456	-1.19 (9.73)	-1.99 (17.13)	0.881	4.31 (9.39)	7.25 (14.88)	0.541
SPATIO-TEMPORAL PARAMETERS									
TRAJECOTRY DEVIATION	1.21 (0.08)	1.41 (0.29)	0.000*	1.07 (0.03)	1.29 (0.24)	0.000*	1.18 (0.06)	1.35 (0.28)	0.000*

V MAX (m/s)	1.29 (0.21)	1.00 (0.23)	0.000*	1.179 (0.22)	0.915 (0.16)	0.000*	1.60 (0.29)	1.24 (0.36)	0.000*
T V MAX (%)	34 (3.45)	38 (9.00)	0.007*	36 (2.89)	38 (12.17)	0.363	38 (3.69)	39 (7.52)	0.205
SMOOTHNESS	-3.11 (0.17)	-3.61 (0.46)	0.000*	-3.13 (0.19)	-3.67 (0.70)	0.000*	-3.25 (0.29)	-3.84 (0.54)	0.000*

PTA = Point of Task Achievement. TD = typically developing, DCP = dyskinetic cerebral palsy. V MAX = maximal speed (in m/s),
T V MAX = timing of maximum speed (in % of reaching cycle). * p < 0.05