Kinematic Analysis of the Upper Extremity During Reaching in the Patients with CP

XC.Liu, R.Lyon, and S.Cope
Musculoskeletal Functional Assessment Center, Dept. of Orthopaedics, Children's Hospital of Wisconsin, Medical College of Wisconsin, Milwaukee, WI 53226

Introduction

Children with spastic cerebral palsy (CP) display a number of difficulties when reaching and grasping, including a slow speed of the affected limb, delay in the initiation of reaching, slowed flexing the fingers to grasp, hyperextension of the fingers, and weak grasp (1,3,4). Clinical scales lack quantitative assessment of functional upper limb movement. Studies using temporal linear data such as movement units (the number of acceleration/deceleration) and peak velocity (2) do not assess angular movement. There is little known data with a reliable upper limb model designed for joint rotation. The goal of this study is to set up an upper limb kinematic model to explore joint movements in CP and typical developing children (TD), and to evaluate variation of their performance.

Statement of Clinical Significance

The model for kinematic analysis of the upper extremity provides quantification of movements in spastic CP. This objective assessment would compliment other clinical measures of upper limb movement.

Methodology

The Electromagnetic Tracking System (ETS) is comprised of a long range StarTrak transmitter (Polhemus Inc., Colchester, VT) with 16 sensors, electronics unit, and the 6D Skill Technologies' motion capture and software (version 2001, Skill Technologies, Inc., Phoenix, AZ). The motion was sampled at a rate of 120Hz.

Five children diagnosed with spastic diplegic cerebral palsy aged from 7 to 17 years and 5 typically developing children aged from 7 to 12 years took part in the study. Three sensors were placed on the body: 1st thoracic spinal process; middle of the humerus; and dorsal aspect of the hand at the dominant limb. The digitizing pen with a 4th sensor digitized the following anatomical landmarks: acromion, stenal notch, opposite sternal notch, anterior and posterior shoulder, medial and lateral epicondyle, radial and ulnar wrist, and middle of the wrist. After digitizing, the trunk with one upper limb skeletal model was established. Through the digitizing, a virtual sensor of the forearm will be defined in the three co-ordinates. All subjects sat comfortably in a standard office chair with flexion of their forearm at 90° on an adjacent table. His/her index finger on affected side was positioned a switch sensor. A ball in the front of subjects was placed on a 2nd switch sensor. The switch sensors were synchronized to record on/off responses. Subjects were instructed to retrieve the ball at a self-selected speed. This was repeated in 3 separate trials.

Linear displacement of the hand and angular movements of the wrist and elbow joint were calculated. Standard Error (SE) for displacement and rotation was also calculated.

Results

During reaching testing, the upper limb model in different subjects showed 2° to 8° SE of angular rotation at the wrist and elbow and less than 1.5 cm SE of linear hand displacement (see table1). The model was also able to detect the differences between TD and patients with CP.

Table 1. Linear and angular displacement in normal and CP (mean and SE)

Parameters	**CP**	**TD**
Linear displacement		
Hand displacement in X axis	5.59 ± 1.42cm	3.67 ± 0.74cm
Hand displacement in Y axis	23.71 ±1.27cm	25.5 ± 0.65cm
Hand displacement in Z-axis	2.71 ±0.41cm	4.49 ± 0.35cm
Angular rotation		
Wrist dosiflexion	0.95±2.16°	7.09± 3.75°
Wrist supination	-8.93±4.89°	-2.47± 4.38°
Wrist adduction	2.04±1.65°	-5.67± 5.45°
Elbow flexion	64.36±3.73°	78.4± 8.21°

Discussion

The upper limb model indicated less variance of liner displacement in the Z-axis in both CP and TD subjects. Variance of angular rotation of the wrist joint is smaller in X-axis in TD subjects and in Z-axis in CP. Measurements on the elbow rotation show larger deviations. CP patients tend to have minimal dorsiflexion, greater pronation and adduction of the wrist as compared to the normal subjects. This method is shown to distinguish differences of the linear and angular movement between TD and CP children. Our model provides a dynamic assessment to motor behavior in relation to impaired proprioception for future study.

Reference

1. Twitchell TE. On the motor deficit in congenital bilateral athetosis. Journal of Nervous and Mental Disease,129:105-132,1951.
2. Utley A, Sugden D. Interlimb coupling in children with hemiplegic cerebral palsy during reaching and grasping at speed. Developmental Medicine and Child Neurology, 40:396-404, 1998.
3. Kluzik, J et al. Quantification of control: A preliminary study of effects of neurodevelopmental treatment on reaching in children with spastic cerebral palsy. Physical Therapy, 70 (2): 65-78, 1990.
4. Rösblad, B. Reaching and eye-hand coordination. In A. Henderson & C. Pehoski (Eds.), Hand function in the child: Foundations for remediation. St. Louis: Mosby, :81-92,1990.