SCIENTIFIC ARTICLE

Affected and Contralateral Hand Strength and Dexterity Measures in Children With Hemiplegic Cerebral Palsy

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Purpose To determine how the affected hemiplegic hand and contralateral dominant hand in children with hemiplegic cerebral palsy compare with age-matched norms for grip strength, pinch strength, and dexterity.

Methods We enrolled 37 children with hemiplegic cerebral palsy (26 boys; average age, 9.8 y). Grip and pinch strength and Box and Blocks Test for dexterity were measured in both hands. Affected and contralateral hands results were analyzed and compared with each other and with norms for age and sex.

Results Affected hands had significantly less grip and pinch strength than the contralateral hands. Subjects transported significantly fewer blocks in one minute with the Box and Blocks Test (mean, 10.8 blocks) with the affected hand than the contralateral hand. Compared with normative values, affected-side grip and pinch strengths were significantly less, whereas contralateral hand grip and pinch strengths were similar. Dexterity in both affected and contralateral hands was significantly less than normative values. Decreased dexterity in the contralateral hand was correlated with decreased nonverbal intelligence quotient.

Conclusions Dexterity of the contralateral hand is diminished in children with hemiplegia. Assessment of the contralateral hand may reveal opportunities for therapeutic intervention that improve fine motor function. *(J Hand Surg Am. 2015;40(5):900–907. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic IV.

Key words Cerebral palsy, dexterity, hemiplegia.

HAND IMPAIRMENT IN CEREBRAL palsy is due to a nonprogressive disturbance of the developing fetal or infant central nervous system that affects movement and posture causing activity limitations.[1] In hemiplegia, the central nervous system disturbance causes impairment on one side of the body. The degree of impairment of the contralateral limb is unclear because strength and dexterity have not been established. In spastic hemiplegia due to cerebral palsy, some have considered the affected hemiplegic hand to be an "assisting hand" and the contralateral hand a "good" and "unimpaired" hand.[2–4]

The affected assisting hand can present with a combination of spasticity, weakness, and dystonia.[5,6] The extent of limb involvement and the degree of abnormal tone patterns vary among individuals. Most commonly in spastic hemiplegia, the resting posture includes elbow flexion, forearm pronation, wrist ulnar deviation and flexion, and thumb adduction and flexion and is caused by muscle imbalance and

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weakness, resulting in deficits in precision grasp, pinch, and dexterity. The severity of motor impairment has been shown to correlate with sensory deficits[7]; the greater the sensory deficit, the more likely there will be some neglect and disuse,[8] putting additional demands on the contralateral hand in activity.

However, it is unclear whether the central nervous system insult that causes hemiplegic cerebral palsy can impair both hands. Is the contralateral hand a "good,"[9] "unimpaired"[2,4] hand" or does it have "subtle deficits"[3–6,9,10]? Some authors have reported delays in the development of anticipatory control of grasp formation,[11] speed in movements,[12] fine finger dexterity,[13] and mild sensory impairments in the contralateral hand.[2,8]

Children with hemiplegic cerebral palsy may present with substantial deficits in hand function, because bimanual activities involve the ability to use the affected and contralateral hands together for grasp and stabilization. Several authors have evaluated bimanual involvement in cerebral palsy,[2,9,12,14–16] but these studies have not compared the contralateral hand with normative values, which have been established for grip strength, pinch strength, dexterity, and stereognosis.[7,8,17–20]

The aim of this study was to determine how the affected hemiplegic hand and contralateral hand in children with hemiplegic cerebral palsy compare with age- and sex-matched norms for grip strength, pinch strength, dexterity, and sensibility.

MATERIALS AND METHODS

Five baseline assessments were administered prospectively as part of a multicenter randomized trial that compared tendon transfer surgery in upper extremity (UE) cerebral palsy with botulinum toxin injections and regular ongoing therapy. The participants were recruited from 7 Shriners Hospitals for Children (see Acknowledgments). Each hospital obtained approval from their local institutional review board, and written consent was obtained from each participant's parent or guardian.

Inclusion criteria for the study were children, aged 4 to 17 years with spastic hemiplegic cerebral palsy who were surgical candidates for pronator teres release, flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer, and adductor pollicis release with extensor pollicis longus based on standard indications as determined by a hand surgeon who participated in the study. Exclusion criteria were House score of 0; previous UE surgery; or UE botulinum injections within 12 months.

Between 2006 and 2013, we enrolled 37 children (26 boys and 11 girls) with an average age of 9.8 years (range, 4–15 y). Four were 4 to 5 years old, 7 were 6 to 7 years old, 12 were 8 to 9 years old, 4 were 10 to 11 years old, 5 were 12 to 13 years old, and 5 were 14 to 15 years old.

The left side was affected in 19 children. Occupational therapists from each site of the study, who were trained with the same protocol, administered assessments to each subject, including grip strength, lateral pinch strength, Box and Blocks Test of manual dexterity, stereognosis, and the Comprehensive Test of Nonverbal Intelligence (CTONI).[17,21] Scenarios from each testing session describing cooperation with the test protocol were made and reviewed to verify patient understanding of the tests.

Grip strength was measured for each hand using a calibrated Jamar hydraulic hand dynamometer (Patterson Medical, Warrenville, IL) following administration guidelines from the American Society of Hand Therapists Clinical Assessment Recommendations, Second edition.[22,23] For the affected hand, attempts to maintain the dynamometer in an upright alignment per testing guidelines were made to correct posturing from spasticity of forearm pronation and wrist flexion. The average of 3 separate maximum voluntary contractions was recorded in kilograms. Available normative data for pediatric grip strength were reviewed. The Ferreira norms were selected which includes ages 6 to 15 years for boys and girls by hand dominance.[20]

Lateral pinch strength was measured using a calibrated Preston pinch gauge (Patterson Medical, Warrenville, IL) following the Mathiowetz 1985 administration guidelines by applying force to the gauge using the pulp of the thumb and the radial lateral side of the middle phalange of the index finger.[17] Three separate maximum voluntary contractions for each hand were exerted and the average was recorded in kilograms. Available normative data for pediatric pinch strength were reviewed. The Ferreira norms were selected, which includes ages 6 to 15 years for boys and girls by hand dominance.

The Box and Blocks Test of unilateral manual dexterity was measured using a standardized test kit with administration guidelines by Mathiowetz et al.[17] The kit includes a large wooden box with a center partition, with 200 2-inch (2.54-cm) wood blocks positioned on one side. The child is asked to quickly move one block at a time from one side of the box over the center partition to the other side. The total number of blocks transported in one minute was recorded for each hand. Normative data have been established for