A Method to Measure Reaching Capacity of Children with Neuromuscular Disorders

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Problem: The measurement of quantitative changes in upper-extremity skills has been limited by the lack of objective standardized measures and, therefore, reaching tasks have been subjectively defined. Solution: A frame made from PVC tubing was constructed to assist in measuring the parameters of vertical, horizontal, and cross midline functional reach of children with neuromuscular disorders, and a measurement protocol was adopted for obtaining the measures of reach. Recommendations for Clinical Practice: Suggestions for assuring consistency in measurements and further exploration of the number of sessions required to determine a child’s best reaching effort are put forth. (Pediatr Phys Ther 2006;18:226–228) Key words: body measures/instrumentation, cerebral palsy, child, neurological disorders, physical therapy/methods, psychomotor skills, upper extremities

INTRODUCTION

Investigators who have measured the upper-extremity functional reach of persons with disabilities have incorporated a wide range of functional skills and used various methods to evaluate objective/quantitative changes in these skills. Upper-extremity functional skills have included grasping and holding toys, touch or grasp toy and timed reached, reaction time of horizontal arm movement, speed and accuracy of computer typing, speed and accuracy using a joystick, finger tapping, and reaction time of manipulating toy cubes.

However, the measurement of quantitative changes in upper-extremity skills has been limited by the lack of objective standardized measures. Outcome measurement tools have included standardized questionnaires, observational functional skills using a video camera and/or a battery of assessments, time to reach and touch or grasp toy or object, time speed and accuracy of typing or using a joystick, and manipulating toy cubes. Whereas each of these tools have been used in an attempt to provide objective evidence (eg, time speed) of change the specific functional skills (eg, reaching, tapping, manipulating toys) were less objectively defined. That is, the exact vertical and horizontal reaching levels attained (ie, in centimeters) were not objectively ascertained. In summary, investigators in previous studies generally restricted upper-extremity functional tasks or skills to horizontal or one-dimensional movements and, therefore, outcomes were determined by observation or timed parameters.

In this report, a frame made from PVC tubing was constructed to assist in measuring the parameters of vertical, horizontal, and cross midline functional reach of children with neuromuscular disorders. Two children, aged 2.3 and 2.5 years with spastic quadriplegic cerebral palsy (CP) participated in evaluating the apparatus and measurement method. Vertical, horizontal, and cross midline reach capacities were determined using the following sequential steps: (1) seated functional skill was determined by quantifying the precise vertical and horizontal locations to which the child was able to reach and touch using the platform frame and (2) to control for the children’s cooperation and motivation on any given session, five sessions were performed in an attempt to identify the child’s “best effort.”

METHODS AND MATERIALS

Participants

The two children were chosen from a group of children receiving physical therapy at an early-childhood education center located in a midwestern metropolitan area.
Both were receiving individual/direct physical therapy from physical therapists within the early-childhood education center. Child A was a 2.3-year-old girl with spastic quadriplegic CP, subsequent to premature birth at 29.5 weeks' gestation with the complication of periventricular leukomalacia. She was diagnosed with CP after one year of age. Child B was a 2.5-year-old girl with spastic quadriplegic CP, subsequent to premature birth at 27 weeks' gestation with complications of periventricular leukomalacia and a cyst in the right white matter of the brain. She was diagnosed with CP and seizure disorder within the first year of life. Both children were assessed using the Gross Motor Function Classification System (GMFCS), and both scored at Level IV. Consent forms were approved by the facility's Human Subjects Committee and the University Institutional Review Board and were signed by the children's parents.

Measuring Horizontal and Cross Midline Functional Reach

Construction of Platform Frame. The frame used to measure horizontal and cross midline functional reach was made of quarter-inch PVC tubing with small plastic platforms secured in position by rivets (Figs. 1–3). The frame was 44.5 cm wide and 50.2 cm high. Five rungs (only four rungs can be seen in Figs. 1–3) were positioned on the frame with the first rung 11.4 cm above the base of the platform and each consecutive rung was 10.2 cm above the previous rung. Attached to the top of each rung were two small rectangular plastic platforms (7.6 cm × 5.1 cm) located on the far right and the far left of the rung, with a horizontal distance of 27.4 cm between each of the small platforms. The frame that held the small platforms was connected to the base of the apparatus, which allowed the frame to slide forward and away from the child to accommodate each child’s arm length. For more specifics in constructing the frame, please correspond with the authors.

Estimate of Cost to Fabricate the Apparatus

The quarter-inch PVC tubing with elbows and Ts for constructing the frame can be bought at most craft or home-improvement stores. For the frame illustrated in this report, two 10-foot lengths of quarter-inch PVC tubing ($1.56 per 10 ft), six elbows ($0.24 each), and 12 Ts ($0.28 each) were needed. The total cost of materials, including the tubing, plastic platforms, glue, and rivets, was approximately $10 to $12.

Reaching Protocol

While the child was seated, a tray was secured in front and the frame was placed on the tray (Fig. 1). The base of the frame was adjusted so that the metacarpophalangeal joints of the child's right hand, when passively moved by the tester, could be placed on the top rung of the frame. This was done to ensure that the top platform was within the child's reach. This position of the frame was marked on the tray and used for all subsequent reach measurements for that child.

The measurement procedure followed that suggested by Rochat. The measurement process began with a cartoon sticker (sticker; 1" × 1" with adhesive side stuck to the finger of the tester and picture side facing the child) placed on the left small rectangular platform (as the child faced the frame) of the first rung (11.4 cm above base) and the child was verbally encouraged to reach for the sticker with one hand and then the other hand (Figs. 2 and 3). The
reach was considered successful when the child touched (ie, not grasped) the sticker (Fig. 3). Whether or not the child was successful at touching the first rectangular platform, the sticker was moved to the small rectangular platform on the opposite side of the same rung. This procedure was followed until the child either did not attempt or could not touch the sticker on either of the small rectangular platforms of a rung within one minute. Successful attempts were recorded according to the rectangular platform (ie, left or right) and rung (first, second, etc) at which the sticker was touched. The measurement session lasted 15 to 30 minutes.

The number of trials to establish “best effort” for the two children followed the procedure used by Washington et al., with the girls evaluated on five different days, with two children followed the procedure used by Washington right) and rung (first, second, etc) at which the sticker was forms of a rung within one minute. Successful attempts were not touch the sticker on either of the small rectangular plat-

was followed until the child either did not attempt or could

could be used depending on the child’s prefer-
ence. It is recommended, however, that to assure consist-
ency, the motivator chosen should be used throughout all

sessions.

The data in Table 1 demonstrate that each child’s perfor-
mance was not consistent across sessions. That is, the

children’s reaching performance ranged from vertical rung level zero to three, and best effort was obtained between session one and session five. Although the apparatus and method proposed in this report would provide objective data (ie, precise horizontal/vertical reach locations) for each session, future studies are necessary to determine number of sessions necessary to identify best effort.

### DISCUSSION

For each child, reaching efforts for each session are presented in Table 1. Seated functional skill was determined by quantifying the precise vertical and horizontal locations that the child was able to reach and touch an object. For this report, objectivity of the seated functional skill was determined by quantifying the precise vertical and horizontal locations that the child was able to reach and touch. This was controlled by constructing a frame with exact horizontal and vertical locations (ie, in centimeters) known at which the child touched the sticker; and the location of the base of the platform with respect to the child was kept constant.

It should be pointed out that the platform could be constructed in the manner described to allow height of the rung levels and positions of small rectangular platforms on the rungs to be adjusted to the needs/abilities of the children being evaluated.

In this report, stickers depicting cartoon figures (see Figs. 1 and 2) were used as motivators. Other types of motivators could be used depending on the child’s preference.

### TABLE 1

Mean, Standard Deviation and Best Effort for Vertical and Horizontal Reach for Child A and Child B

<table>
<thead>
<tr>
<th>Session</th>
<th>Vertical Level Reached</th>
<th>Right Hand</th>
<th>Left Hand</th>
<th>Vertical Level Reached</th>
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<th>Left Hand</th>
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<tr>
<td></td>
<td>Rectangular Platform</td>
<td>Child A</td>
<td>Child B</td>
<td>Rectangular Platform</td>
<td>Child A</td>
<td>Child B</td>
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### REFERENCES


