Validation of the Shriners Hospital for Children Upper Extremity Evaluation (SHUEE) for Children with Hemiplegic Cerebral Palsy

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Background: The Shriners Hospital for Children Upper Extremity Evaluation (SHUEE) is a video-based tool for the assessment of upper extremity function in children with hemiplegic cerebral palsy. This tool includes spontaneous functional analysis and dynamic positional analysis and assesses the ability to perform grasp and release. The purpose of the present study was to assess the reliability, concurrent validity, and construct validity of this instrument.

Methods: The Shriners Hospital for Children Upper Extremity Evaluation studies for eleven subjects with hemiplegic cerebral palsy were selected for the evaluation of intraobserver and interobserver reliability. Concurrent validity was determined through analysis of the Shriners Hospital for Children Upper Extremity Evaluation, Pediatric Evaluation of Disability Inventory, and Jebson-Taylor Test of Hand Function scores for twenty children. Construct validity was determined through analysis of Shriners Hospital for Children Upper Extremity Evaluation scores for eighteen children before and after flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer.

Results: The absolute mean differences between the two scoring sessions for three raters were 1.2 and 1.0 for the spontaneous functional analysis and the dynamic positional analysis, respectively. Although the mean differences were significantly different from 0 ($p < 0.001$ and $p = 0.003$), the differences were small and not clinically important with regard to the total possible score. There was excellent intraobserver reliability between the two sessions with regard to both spontaneous functional analysis ($r = 0.99$) and dynamic positional analysis ($r = 0.98$). Assessment of interobserver reliability revealed absolute mean differences between four raters of 3.8 and 3.7 for the spontaneous functional analysis and the dynamic positional analysis, respectively. These differences were significantly different from 0 ($p < 0.001$); however, the magnitudes of these differences were not important with regard to total score or clinical interpretation. There was excellent interobserver reliability for both the spontaneous functional analysis ($r = 0.90$) and the dynamic positional analysis ($r = 0.89$). There was 100% agreement within and between examiners for the grasp-and-release section. The Shriners Hospital for Children Upper Extremity Evaluation showed fair correlation with the self-care scaled score from the Pediatric Evaluation of Disability Inventory ($r = 0.47$) and good inverse correlation with the non-dominant total time section of the Jebson-Taylor test ($r = -0.76$). The Shriners Hospital for Children Upper Extremity Evaluation wrist score improved for all eighteen subjects after the flexor tendon transfer, and the mean improvement was significant ($p < 0.001$).

Conclusions: The present study establishes the clinical reliability, concurrent validity, and construct validity of the Shriners Hospital for Children Upper Extremity Evaluation for the assessment of upper extremity function in children with hemiplegic cerebral palsy.

Clinical decision-making and the assessment of the outcome of treatment of the upper extremity in children with cerebral palsy have been based primarily on data derived from physical examination and radiographs of the hand and wrist[1-29]. Information provided by the clinical examination includes range of motion and joint stability, the presence of dynamic or myostatic muscle deformity, sensibility, stereognosis, and motor control (primarily the ability to grasp and release).

The reliability of such information, and its relation to function, are presumed but have never been directly established. Radiographs of the hand and wrist have been utilized to assess joint alignment and skeletal maturity and to help to determine the need for and timing of skeletal stabilization of the wrist and the metacarpophalangeal joint of the thumb.

Quantitative analysis of upper extremity function, performed to improve clinical decision-making and outcome assessment, has involved the use of dynamic fine-wire electromyography, kinematic measurement with electrogoniometers, and biomechanical modeling[8,9,13,30,31]. These technologies and techniques are associated with substantial clinical limitations, have not been widely accepted, and are currently utilized at only a few centers around the world.

Standardized clinical tests of hand and upper extremity function in children have been developed to improve the quality of the information that is available for clinical decision-making and outcome assessment[14,32-43]. Such tests typically have focused on elements of impairment, with little emphasis on the assessment of disability and societal limitations. Although these evaluation tools may consider task completion (i.e., whether the subject can perform a task, as determined by the time to completion), none have considered how the subject completes such functional tasks. Few of these tests meet current standards for validity and reliability, and consensus concerning the optimal evaluation tool for use with specific disease processes has not been established.

In 1996, the Shriners Hospital for Children Upper Extremity Evaluation (SHUEE) was developed to assess upper extremity function in children with hemiplegic cerebral palsy. The SHUEE is a video-based study that is performed by an occupational therapist with use of a standardized set of objects and tasks. Video camera positioning is also standardized. The complete tool (including the history, physical examination, and video documentation sections) takes approximately fifteen minutes to administer and is scored by the occupational therapist following a review of the video at any time after the study. The video and the scoring forms are maintained within the subject's medical record.

In addition to the measures of impairment mentioned above (e.g., range of motion, joint stability, and spasticity), the tool was designed to include an assessment of spontaneous functional use of the affected extremity during a series of functional tasks as well as a dynamic segmental positional analysis of the affected extremity when these tasks were performed on demand with the involved extremity. The SHUEE was designed to determine the potential for improved function by identifying the degree of spontaneous use (presumably, the greater the spontaneous use, the greater the potential for improved use) and the dynamic segmental alignment of the affected extremity during on-demand use (directing interventions toward impairment elements that disrupt function by compromising upper extremity segmental alignment). The SHUEE was modified during the first years of its use, and its applications have been broadened to include the trending of upper extremity use and alignment over time, the selection of interventions (including orthotic, pharmacologic, and surgical interventions), and the determination of outcome in technical and functional domains following such interventions.

Over the last eight years, we have utilized the SHUEE for the evaluation of 200 children with hemiplegic cerebral palsy. Evaluation and, ultimately, utilization of the SHUEE by the community at large requires that the tool be validated. In psychometrics, a valid measure is one that measures what it is supposed to measure[44]. The exact nature of validity, and how to establish it, are topics of great controversy. It is more practical to consider validity not as a single, absolute concept, but rather as a contingent construct related to the processes and intentions of particular research methodologies and designs[44-47]. The goals of the current study were to establish three types or components of validity for the SHUEE: (1) reliability, as determined by an analysis of intraobserver and interobserver variability in the scoring of the SHUEE; (2) concurrent validity, as determined by the comparison of SHUEE, the Pediatric Evaluation of Disability Inventory (PEDI), and the Jebson-Taylor Test of Hand Function (JTT) scores from the same cohort; and (3) construct validity, as determined by the analysis of SHUEE scores before and after a common orthopaedic surgical intervention (flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer) designed to improve wrist alignment[48-50].

Materials and Methods

The study was evaluated and approved by our hospital's institutional research committee.

Description of the SHUEE

The SHUEE is a video-based evaluation that consists of two sections (see Appendix). The first section evaluates the subject through standard measurements of active and passive range of motion from the shoulder to the fingers. Spasticity is evaluated with use of the modified Ashworth scale[51]. A history-based assessment of the subject's performance of seven selected activities of daily living and a subjective assessment of patient/family goals are also included. Because these are all standard measures that have been utilized in the community at large for many years, the current study does not address the issue of their validity. The second section has three components. The first component (spontaneous functional analysis) evaluates the spontaneous use of the involved extremity with respect to nine common tasks with use of a modification of the House functional classification system[23,24,29]. The second component (dynamic positional analysis) involves an assessment of the segmental alignment of the affected extremity (thumb, fingers, wrist, forearm, and elbow) during the performance of sixteen selected tasks on demand. Possible alignments for each segment are based on visual observational analysis and have been clearly defined in the instruction manual that accompanies the test. The final component (grasp-and-release analysis) evaluates the subject's ability to perform grasp and release of the digits with the wrist held in flexion, neutral, and extension. Numerical scoring of the SHUEE is done to facilitate comparison between studies performed on the same subject over a period of time,

TABLE I Intraobserver Reliability

Measure	Score*		Absolute Value of Difference†	Pearson Correlation Coefficient (r)
	First Assessment	Second Assessment		
Spontaneous functional analysis	23.8 ± 11.3	23.5 ± 1.0	1.2 ± 1.5 (0, 5)	0.99
Dynamic positional analysis	47.5 ± 11.7	47.6 ± 11.9	1.0 ± 1.9 (0, 7)	0.98

*The data are given as the mean and the standard deviation. †The values are given as the mean and the standard deviation, with the minimum and maximum values in parentheses. $P < 0.001$ for spontaneous functional analysis, and $p = 0.003$ for dynamic positional analysis (paired t test).

such as before and after an intervention (see Appendix). Spontaneous functional analysis assessments are scored on a scale of 0 (complete neglect) to 5 (spontaneous, independent function). The maximum possible spontaneous functional analysis score is 45. Dynamic positional analysis alignments for each anatomical segment are scored on a scale from 0 (maximal malalignment) to 3 (optimal alignment). The maximum possible total dynamic positional analysis score is 60 (with a maximum of 12 each for the thumb, fingers, wrist, forearm, and elbow). The grasp-and-release assessment is scored on a scale of 0 (unable to perform grasp or release) or 1 (able to perform grasp and release) for each of the three wrist alignments. The maximum possible grasp-and-release score is 6. For clinical utilization, the scores are expressed as a percentage of the maximum possible score (corresponding with optimal segmental alignment) for each section.

Reliability

The SHUEE studies for eleven subjects were selected for the evaluation of intraobserver and interobserver reliability. This purposeful sample was selected with use of the following inclusion criteria: a diagnosis of hemiplegic cerebral palsy, no previous surgical interventions on the involved upper extremity, and complete documentation of the index SHUEE evaluation.

Six subjects were girls, and five were boys. The mean age at the time of the SHUEE study was eleven years and ten months (range, six years and eleven months to thirteen years and nine months). All subjects had hemiplegic cerebral palsy, with the right side involved in six subjects and the left side involved in the remaining five. Intraobserver reliability was determined by three occupational therapists (including L.C.P. and L.V.W.), each of whom had completed a standardized training program for the SHUEE. Each therapist graded each of the eleven studies, in a blinded fashion, on two occasions separated by one to three weeks. Interobserver reliability was determined among four occupational therapists (including L.C.P. and L.V.W.) who had all been similarly trained. For this analysis, each therapist graded each of the eleven studies, in a blinded fashion, on a single occasion. Statistical analyses of intraobserver and interobserver reliability (involving an analysis of the mean absolute value of thirty-three differences for the former and sixty-six differences for the latter) were performed with use of the Student paired t test (with the null hypothesis being that paired differences were equal to zero). Linear relationships between assessments by the same examiner were described with use of Pearson correlation coefficients. The intraclass correlation coefficient was used to assess interobserver reliability. Weighted kappa was used to assess agreement between categories on the grasp-and-release scale. The level of significance was set at $p < 0.05$. All correlation coefficients were categorized as excellent ($r \geq 0.80$), good ($r < 0.80$, $r \geq 0.60$), fair ($r < 0.60$, $r \geq 0.40$), or poor ($r < 0.40$).

Concurrent Validity

The SHUEE, PEDI, and JTT were performed and graded by a single occupational therapist (L.C.P.) for twenty subjects with hemiplegic cerebral palsy. Nine subjects were female, and eleven were male. The right side was involved in eight subjects, and the left side was involved in the remaining twelve. The mean age at the time of the multiple evaluations was ten years and eleven months (range, six years and seven months to fifteen years and eight months). All three tests were performed for each subject at the same evaluation session, in random order. The self-care scaled score from the PEDI and the nondominant total time score from the JTT were compared with the spontaneous functional analysis percentage score from the SHUEE[48-50]. Linear relationships between each of the three tools were analyzed with Pearson correlation coefficients. The level of significance was set at $p < 0.05$. Correlation coefficients were categorized as excellent ($r \geq 0.80$), good ($r < 0.80$, $r \geq 0.60$), fair ($r < 0.60$, $r \geq 0.40$), or poor ($r < 0.40$).

Construct Validity

Preoperative and postoperative SHUEE studies were analyzed for eighteen subjects with hemiplegic cerebral palsy who were managed with flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer to improve wrist position. There were six female and twelve male subjects. The right side was involved in twelve subjects, and the left side was involved in the remaining six subjects. The mean age at the time of surgery was eleven years and two months (range, six years and four months to fourteen years and eight months). The mean age at the time of the follow-up SHUEE evaluation was twelve years and eight months (range, seven years and two months to eighteen years). The mean time between surgery and the postoperative SHUEE evaluation was one year and eleven months (range, six months to four years and six months). Concomitant surgical procedures on the forearm, fingers, and thumb

TABLE II Interobserver Reliability

Measure	Score*				Absolute Value of Difference†	Intraclass Correlation Coefficient (r)
	Therapist 1	Therapist 2	Therapist 3	Therapist 4		
Spontaneous functional analysis	22.6 ± 11.4	23.6 ± 11.3	25.3 ± 12.1	22.8 ± 11.7	3.8 ± 3.5 (0, 13)	0.90
Dynamic positional analysis	45.9 ± 13.2	49.0 ± 11.3	47.5 ± 11.5	45.4 ± 11.4	3.7 ± 4.0 (0, 16)	0.89

*The values are given as the mean and the standard deviation. †The values are given as the mean and the standard deviation, with the minimum and maximum values in parentheses. P < 0.001 for spontaneous functional analysis and dynamic positional analysis (paired t test).

were performed for fifteen of the eighteen subjects at the time of the flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer; these procedures included thumb reconstruction consisting of web space release, metacarpophalangeal arthrodesis, and extensor pollicus longus rerouting (fourteen subjects); fractional lengthening of the flexor digitorum superficialis and/or profundus (seven subjects); release of the pronator teres and/or quadratus (six subjects); and fractional lengthening of the flexor pollicus longus (four subjects). Preoperative and postoperative spontaneous functional analysis scores (eighteen subjects), dynamic positional analysis scores for the wrist (eighteen subjects), and grasp-and-release scores (fourteen subjects), were compared with use of the Student paired t test. The level of significance was set at $p < 0.05$.

Results

Reliability

The results for the assessment of intraobserver and interobserver reliability of the spontaneous functional analysis and dynamic positional analysis are presented in Tables I and II, respectively. The absolute value of the mean difference between the two scoring sessions for the three raters was 1.2 and 1.0 for the spontaneous functional analysis and the dynamic positional analysis, respectively. Although the mean differences were significantly different from 0 ($p < 0.001$ for the spontaneous functional analysis and $p = 0.003$ for the dynamic positional analysis), the differences were small and were not clinically important with regard to the total possible score (45 for spontaneous functional analysis and 60 for dynamic positional analysis). Pearson correlation coefficients indicated excellent intraobserver reliability between the two sessions for both the spontaneous functional analysis ($r = 0.99$) and the dynamic positional analysis ($r = 0.98$). The assessment of interobserver reliability among the four raters revealed absolute mean differences of 3.8 and 3.7 for the spontaneous functional analysis and the dynamic positional analysis, respectively. These differences were significantly different from 0 ($p < 0.001$ for both the spontaneous functional analysis and the dynamic positional analysis); however, the magnitudes of these differences were not important with regard to total score or clinical interpretation. Intraclass correlation coefficients indicated excellent interobserver reliability for both the spontaneous functional analysis ($r = 0.90$) and the dynamic positional analysis ($r = 0.89$). There was 100% agreement within and between examiners for the grasp-and-release section of the SHUEE, with weighted kappa statistics equal to 1.00 for both analyses. Eight of the eleven subjects received a grasp-and-release score of 6 (indicating the ability to perform grasp and release with the wrist in all positions), two subjects received a grasp-and-release score of 2 (indicating limited grasp and/or release function), and one subject received a grasp-and-release score of 0 (indicating the inability to perform grasp or release with the wrist in any position).

Concurrent Validity

The spontaneous functional analysis portion of the SHUEE showed fair correlation ($r = 0.47$) with the self-care scaled score of the PEDI (Fig. 1). The limited range of scores on the PEDI reflected a ceiling effect for the population of patients with hemiplegic cerebral palsy that the SHUEE was designed to study. The spontaneous functional analysis portion of the SHUEE showed good inverse correlation ($r = -0.76$) with the nondominant total time section of the JTT (Fig. 2). Higher scores on the spontaneous functional analysis section of the SHUEE, indicating better spontaneous use of the involved extremity, correlated with shorter times for task completion by the involved extremity in the JTT.

TABLE III Construct Validity

Measure	Score*		Difference*	P Value (Paired T Test)
	Before Tendon Transfer	After Tendon Transfer		
Spontaneous functional analysis	26.7 ± 5.9 (14, 38)	30.1 ± 5.9 (21, 41)	3.4 ± 5.4 (–5, 13)	0.017
Dynamic positional analysis wrist	5.3 ± 1.6 (4, 8)	11.7 ± 0.7 (10, 12)	6.4 ± 1.6 (4, 8)	<0.001
Grasp and release	5.36 ± 0.9 (2, 6)	5.43 ± 1.5 (4, 6)	0.07 ± 1.1 (–2, 2)	0.82

*The values are given as the mean and the standard deviation, with the minimum and maximum values in parentheses.

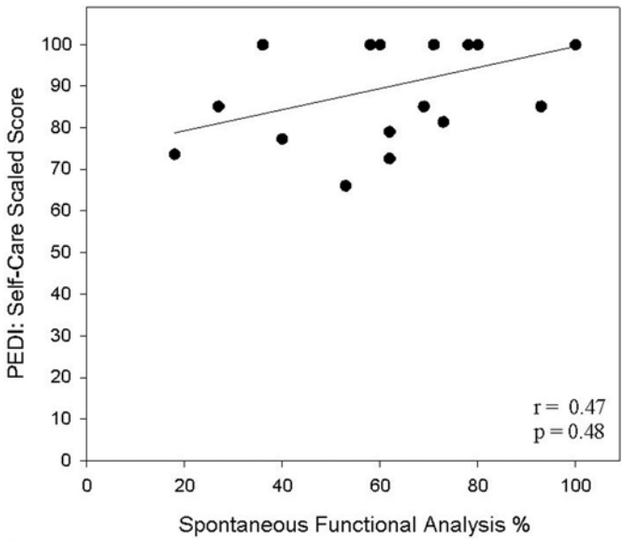

Fig. 1

Illustration showing the correlation between the spontaneous functional analysis score of the Shriners Hospital for Children Upper Extremity Evaluation (expressed as a percentage of the maximum possible score) and the self-care scaled score of the Pediatric Evaluation of Disability Inventory.

Construct Validity

The results of the SHUEE analyses performed before and after flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer to improve wrist alignment are presented in Table III. The change in the mean spontaneous functional analysis score following surgery (3.4 of 45) was significantly different from 0 ($p = 0.017$). However, the magnitude of this difference was not clinically important with regard to the total score or clinical interpretation. The spontaneous functional analysis score was improved for eleven subjects (range of improvement, 2 to 13), unchanged for three subjects, and worse for four subjects (range of worsening, 1 to 5). The change in the mean dynamic positional analysis wrist score (6.4 of 12) following surgery was significantly different from 0 ($p < 0.001$). The dynamic positional analysis wrist score improved for all eighteen subjects (range of improvement, 4 to 8). The mean postoperative dynamic positional analysis wrist score was 11.7 (range, 10 to 12) of a total possible score of 12, indicating excellent wrist alignment following the tendon transfer. The change in the mean grasp-and-release score following surgery (0.07 of 6) was not significantly different from 0. The grasp-and-release score was improved for three subjects (range of improvement, 1 to 2), unchanged for nine subjects, and worse for two subjects (with the score worsening by 1 for both subjects). All of the subjects with no change in the grasp-and-release score had presurgical scores of 6, indicating the ability to perform grasp-and-release functions with the wrist in all positions before surgery. Both subjects with worsening of the grasp-and-release score showed loss of release function with the wrist held in an extended position.

Discussion

There is little consensus with regard to clinical decision-making and the assessment of technical and functional-domain outcomes related to upper extremity interventions in children with hemiplegic cerebral palsy. This is due, in part, to the absence of an evaluation tool that specifically considers the pathophysiology of cerebral palsy and the functional challenges faced by subjects with hemiplegia. Most of the existing evaluation tools are not disease-specific and initially were designed to assess subjects with a range of conditions[32,34-37,40,42,49,52-55]. Such instruments focus on whether the subject can (or cannot) complete a selected task, frequently utilizing the time to completion of the task as a measure of functional ability. This provides no information that is of benefit for clinical decision-making, and is, at best, an indirect or partial measure of functional-domain outcome in this patient population. The SHUEE was designed to evaluate both whether and how a child with hemiplegic cerebral palsy completes functional tasks. The potential for improved function is determined by identifying the degree of spontaneous use; presumably, the greater the spontaneous use, the greater the potential for improved functional use. Assessment of the dynamic segmental alignment of the affected extremity during on-demand use identifies impairment elements that disrupt function by compromising upper extremity segmental alignment, information that is relevant to clinical decision-making and outcome assessment.

Data based on the quantitative assessment of static and dynamic alignment of the upper extremity during functional analysis, utilizing biomechanical modeling and computer-based movement measurement capture, presumably would be the

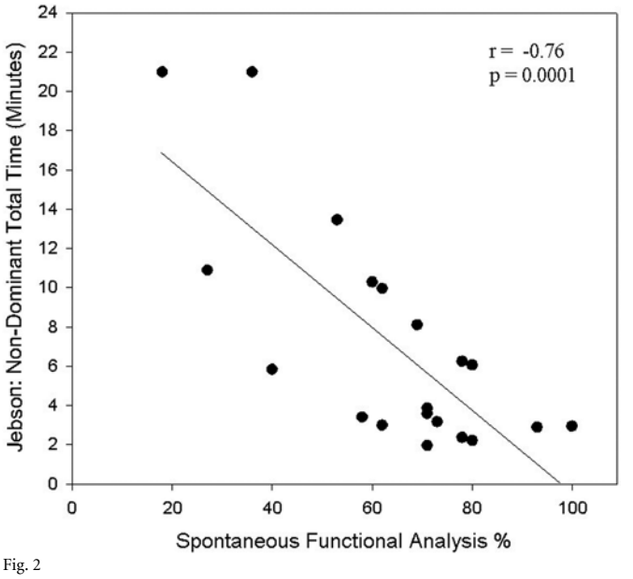

Fig. 2

Illustration showing the correlation between the spontaneous functional analysis score of the Shriners Hospital for Children Upper Extremity Evaluation (expressed as a percentage of the maximum possible score) and the nondominant total time section of the Jebson-Taylor Test of Hand Function (expressed in minutes).

most accurate, reliable, and objective[13,23-25,30,31]. Unfortunately, substantial technical and clinical challenges have limited the development and application of such a paradigm. The SHUEE utilizes a more qualitative approach to the analysis of dynamic functional alignment. The quality of the data generated by this approach is optimized by the evaluation of selected tasks, clear definitions of the possible upper extremity segmental alignments, and standardization of the video-capture technique. The occupational therapists who participated in the evaluation of intraobserver and interobserver reliability in the current study had one to twenty-two years of clinical experience. Each therapist completed a standardized training program based on a comprehensive SHUEE training manual, which included a key interpretation video (consisting of two examples of each of the potential scores), and a practice case video (consisting of five prescored studies). Following such a program, both the intraobserver and interobserver clinical reliability of the SHUEE were determined to be excellent. To achieve such a degree of clinical reliability with a qualitatively-based evaluation tool requires consistent, comprehensive training[43]. All training materials appear in the electronic supplement to this article, and also are available from us on request. We do not encourage or support the use of the SHUEE without completion of the training program. Utilization of the SHUEE within and between institutions will require coordinated training efforts. The current study did not evaluate the contribution of intrasubject variability to the overall reliability of the SHUEE. Performance of motor tasks by children with cerebral palsy may be affected by a wide range of variables, including anxiety, fatigue, and hunger. A test-retest study of subjects would be necessary to establish the impact of intra-subject variability on the overall reliability of the SHUEE.

The principal challenge in establishing concurrent validity for the SHUEE was the lack of a widely accepted "gold standard" evaluation tool. The lack of such a tool was the driving force behind the development of the SHUEE. Following a comprehensive review of existing evaluation tools, the PEDI was selected for comparison on the basis of the fact that it had been validated, had been used as a benchmark for the validation of other tools, and was familiar to the occupational therapists at our institution following its use in a previous study[38,42,49,56]. The JTT was also selected for the determination of concurrent validity for similar reasons, including its widespread use in the literature and its consideration of nondominant extremity function[33,37,40,48,50,54]. The fair correlation between the self-care scaled score of the PEDI and the spontaneous functional analysis score of the SHUEE was a consequence of a narrow range of relatively high scores on the PEDI and a wider range of scores on the SHUEE. The PEDI is not extremity-specific, and children with hemiplegic cerebral palsy are frequently able to compensate for unilateral upper extremity impairments by utilizing the contralateral extremity. As a result, the PEDI was thought to exhibit a ceiling effect in this study group of children with hemiplegic cerebral palsy. The SHUEE, by assessing the spontaneous functional use of the involved extremity, provided greater discriminatory ability and thus we believe that it is more appropriate for use in this patient population. The good inverse correlation between the nondominant total time section of the JTT and the spontaneous functional analysis section of the SHUEE reflects the linkage between spontaneous functional use and time to task completion for the involved upper extremity in children with hemiplegic cerebral palsy. Although this linkage is intuitive, it has not been previously established, to our knowledge.

Construct validity for the SHUEE was determined by evaluating the dynamic positional analysis scores for the wrist before and after flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer. This surgical procedure was first described in 1942 and was selected for review because it has been widely accepted as the optimal treatment for wrist flexion deformity in subjects with hemiplegic cerebral palsy[1,8,11,15,18-22,24,26-28,57,58]. The indications for the flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer in the study group were spontaneous functional analysis scores that indicated at least poor passive assist function of the involved extremity (scores of 2 on all tasks, for a total spontaneous functional analysis score of 18 of 45, or ≥40%), and dynamic positional analysis wrist scores that indicated wrist flexion or neutral alignment in all tasks (scores of 2 on each task, for a total dynamic positional analysis wrist score of 8 of 12, or ≤67%). Additional, associated surgical procedures for the thumb and fingers were recommended on the basis of the dynamic positional analysis scores for the thumb and fingers as well as grasp-and-release scores. Additional, associated surgical procedures for the forearm were recommended on the basis of the dynamic positional analysis scores for the forearm. Postoperative SHUEE analyses following flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer showed improved wrist position for all subjects, although the duration of follow-up was relatively short for some. This clinical result is consistent with that reported by other investigators, and the significant improvement in the dynamic positional analysis scores for the wrist supports the construct validity of the SHUEE.

It has long been recognized that failure to appreciate and address static or dynamic tightness of the extrinsic finger flexors at the time of flexor carpi ulnaris to extensor carpi radialis brevis tendon transfer can result in a diminished ability to perform finger release function with the wrist in the corrected extension alignment[1,5,8-10,12,13,18,26-28,58]. The grasp-and-release outcome scores, which demonstrated maintenance or improvement in twelve of fourteen subjects, supported the efficacy of our preoperative clinical decision-making matrix for recommending fractional lengthening of selected finger flexors on the basis of the dynamic positional analysis scores for the fingers as well as the grasp-and-release scores. It has long been assumed that the improved segmental alignment and range of motion achieved following soft-tissue and skeletal surgery on the upper extremity in subjects with hemiplegic cerebral palsy would result in improved functional use of the extremity[1,5,8-10,12,13,18-21,26-28,58]. In the current study, the improvement in the mean spontaneous functional analysis score following surgery was not clinically significant, with only eleven

of eighteen subjects showing improved scores. Additional study is needed in order to determine if this is due to the intervention being ineffective or the SHUEE not being sensitive enough to identify a difference, or both. The SHUEE can provide a mechanism for additional analysis of the relationship between dynamic alignment of the upper extremity and spontaneous functional use in children with hemiplegic cerebral palsy. Patient and parent satisfaction domain outcomes, which include both functional and cosmetic components, are not addressed by the SHUEE.

In conclusion, the current study provides evidence regarding the clinical reliability, concurrent validity, and construct validity of the spontaneous functional analysis, dynamic positional analysis, and grasp-and-release sections of the SHUEE. The achievement of an acceptable level of reliability with a qualitatively-based evaluation tool such as the SHUEE requires consistent, comprehensive training and frequent clinical application to attain and maintain a high degree of proficiency[41,43]. Evaluation and utilization of this tool by the community at large should be preceded by complete review of the training materials that have been developed.

Appendix

eA The forms, scoring sheet, and training manual used for the SHUEE are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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