Melbourne Assessment of Unilateral Upper Limb Function: construct validity and correlation with the Pediatric Evaluation of Disability Inventory

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The Melbourne Assessment of Unilateral Upper Limb Function (Melbourne Assessment) is an evaluation tool that objectively measures upper-extremity function in children with cerebral palsy (CP). This study investigates how well performance on the Melbourne Assessment relates to the child's actual performance in functional tasks. Eighteen children with CP (5 to 14 years of age; nine males, nine females) were assessed using the Melbourne Assessment and the Pediatric Evaluation of Disability Inventory (PEDI). Five children had spastic quadriplegia, eight had spastic diplegia, two had spastic hemiplegia and diplegia, two had athetosis, and one had hypotonic quadriplegia with mobile ventilator dependence. Children's performances were statistically correlated using Spearman's rho to establish the relation between these tools. Very high correlation coefficients were calculated between the Melbourne Assessment and self-care (0.939) and mobility domains (0.783) of the PEDI and the overall functional skills section of the PEDI (0.718). The Melbourne Assessment demonstrates excellent construct validity for upper limb functioning.

Medical and allied health professionals aim to carry out research which substantiates the practices they use to improve the function of children with cerebral palsy (CP). The success of ever-expanding pharmacological, surgical, and therapeutic interventions that aim to improve upper-limb function is difficult to measure due to the lack of reliable and valid outcome measurement tools that are specific to upper-limb function.

Quality of movement in the upper extremities is the result of an interplay among cognitive, sensory, perceptual, cultural, and motor factors. Objectively measuring the hand function of a child with CP is a difficult task because of the complexity of upper-extremity function. The skill with which a child with CP uses their hands is dependent on the location and extent of brain damage, personality factors, and the unique strengths of the child. The difficulty in defining upper-extremity quality of movement in children with CP is evidenced by the scarcity of measurement tools.

The Melbourne Assessment of Unilateral Upper Limb Function (Melbourne Assessment; Randall et al. 1999) is an evaluative tool that measures unilateral upper-extremity quality of movement in children from 5 to 15 years of age. Unilateral measurement of function is useful as many interventions are unilateral or concerned with improvement in the dominant limb. The Melbourne Assessment is applicable to children challenged by any neurological dysfunction. Thus, the Melbourne Assessment is a unique tool applicable to a broad population of children with CP.

The test items of the Melbourne Assessment were selected to represent the theoretical construct of upper-limb function. Construct validity was established during development and review of the assessment. However, more research is necessary to confirm that this tool measures the construct, that is, that test items actually relate to the child's ability in tasks of daily living. Agreement between performance on this assessment and a sound assessment tool that measures ability in functional living skills will substantiate the construct validity of the Melbourne Assessment.

The Paediatric Evaluation of Disability Inventory (PEDI; Haley et al. 1992) is a psychometrically sound outcome measure that quantifies a child's level of ability and dependence in many functional activities of daily living. Well substantiated in the literature (Hinderer and Gupta 1996, Ketelaar 1998), the PEDI measures task performance in the areas of self-care, mobility, and social functioning.

The purpose of this study was to determine the construct validity of the Melbourne Assessment by correlating performance with the PEDI. In addition, the practical aspects of using this tool in clinical practice were investigated.

Method

PARTICIPANTS

The study population was a convenience sample which consisted of 18 children recruited from a paediatric therapy centre in suburban Chicago, IL, USA. All children had a diagnosis of CP. The children were between 5 and 14 years of age. Nine were left-hand dominant and nine were right-hand dominant. Of the 18 children, 12 were female (two had spastic quadriplegia, eight had spastic diplegia, and two had spastic hemiplegia and diplegia), and six were male (three had spastic quadriplegia, two had athetosis, and one had hypotonic quadriplegia with mobile ventilator dependence).

Criteria for selection included the ability to understand and respond to simple directions, and normal hearing and vision (children wearing corrective lenses were permitted). Parents of all participants gave written consent for their child to be included in the study.

MEASURES

Psychometric properties of the PEDI

The PEDI has been favourably investigated in numerous studies (Feldman et al. 1990, Reid et al. 1993, Ziviani and Wright 1995, Hinderer and Gupta 1996, Nichols and Case-Smith 1996, Ketelaar et al. 1998). Such studies support reliability and validity of the PEDI as an evaluative tool capable of detecting the presence, extent, and area of a functional delay in children with physical impairment or combined physical and cognitive impairment. Although standardized using a normally developing population aged 6 months to 7 years 6 months, the authors promote applicability to older children if their functional development is delayed.

Coster and Haley (1992) developed the test based on a disability construct that measures how the child is functioning with their impairment and within the context of their daily life. The instrument does not measure how a child achieves function or any aspect of quality of movement. The PEDI comprises three content domains: self-care, mobility, and social function. The self-care domain consists of 73 capability items in 15 skill areas. The mobility domain has 59 items across 13 areas and the social functioning has 65 items across 13 areas. Test items are criterion-referenced; a score of one is achieved if the child is capable of performing the activity in most situations.

The PEDI has three types of measurement scales: functional skills, caregiver assistance, and modifications measure. Each measurement scale includes the three content domains. The functional skill scales assess the child's actual performance in functional activities within the three domains. This scale will be scored and used in this study, as it represents what the child can do without the assistance of a caregiver.

Psychometric properties of the Melbourne Assessment

The Melbourne Assessment was developed and designed by two occupational therapists and a paediatrician, following extensive investigation of techniques for objectively measuring upper-limb movement in children with CP (Reddihough et al. 1987, 1990, 1991; Bach et al. 1994). The Melbourne Assessment has three purposes as detailed in the manual. These are (1) to evaluate changes in upper-limb function following treatment interventions including therapeutic, surgical, neurological, and mechanical interventions; (2) to allow comparison between the performances of two children over time, following specific treatment intervention; and (3) to provide information to parents, teachers, and others about the child's progress in a treatment programme. Thus, this assessment is intended as an evaluative tool and outcome measure.

The test comprises 16 criterion-referenced items (Table I) that involve reach, grasp, release, and manipulation. The assessment is intended for use with children aged 5 to 15 years with neurological impairment of upper-limb function. The child is evaluated sitting at a table, or if unable to sit independently, sitting in their usual form of support (i.e. wheelchair) with an appropriate tray, or table. The entire assessment is administered using the standardized directions and is videotaped for precise scoring at a later time. The test comprises manual, score sheet (Appendix I), and kit with items: paper, single message voice output switch, three specifically sized containers (small, medium, and large), a pellet, a 25 cm 'magic wand', a coloured cube, and a biscuit (cookie) needs to be supplied. To ensure adherence to standardized testing procedures, the authors recommend use of the test kit as it is sold.

Items were selected, following review by expert consultants, to meet the criteria of being (1) representative of challenging and frequently problematic movement for children with CP, (2) related to functional tasks, (3) easy to administer to the target population, and (4) of placing minimal demands on other skills that may reduce the child's performance, such as cognition, perception, and language. Internal consistency of test items was determined, and this indicated that the items correlated significantly with each other and with the total score. An initial reliability study resulted in the final 16-item format (Johnson et al. 1994).

The Melbourne Assessment is scored on the child's performance as the task is attempted. Components of each test item are measured and make up the criteria for scoring, including range of movement, target accuracy, fluency, grasp, accuracy of release, finger dexterity, and speed depending on the item. Appendix II demonstrates a sample of the scoring criteria. Video recording is used for precise observation. The definitions and criteria for all scored items are extensively and simply defined in the manual. Criteria vary on most items and are geared toward scoring the most important characteristics of the item. The score sheet consists of 3-, 4-, or 5-point scales that allocate scores on the 16 items, with 37 subscores, according to success and quality of movement. The sum of the individual scales of the 37 subscores is recorded as a raw score and converted to a percentage score. For the complete test, the total possible score is 122 points. A higher percentage score indicates better quality in upper-limb movement based on the test items.

Content validity was established during the development and review of the assessment in three ways: reference to the

Table I: Melbourne Assessment of Unilateral Upper Limb Function test items (Randall et al. 1999)

Item	*Task*
1	Reach forwards
2	Reach forwards to an elevated position
3	Reach sideways to an elevated position
4	Grasp of crayon
5	Drawing grasp
6	Release of crayon
7	Grasp of pellet
8	Release of pellet
9	Manipulation
10	Pointing
11	Reach to brush from forehead to back of neck
12	Palm to bottom
13	Pronation/supination
14	Hand to hand transfer
15	Reach to opposite shoulder
16	Hand to mouth and down

literature to ascertain skills that are considered to be closely related to functional ability; review of existing evaluations relevant to children with CP; and an expert panel of professionals experienced in the skills of children in the target population. Due to the lack of similar psychometrically sound assessments of upper-limb function, concurrent validity has been established using statistical correlation analysis of the subjective judgment of an expert panel of four. Johnson and colleagues (1994) described the evaluation of 11 children with CP, who were evaluated using the Melbourne Assessment and by the various methods of the panel. Strong agreement occurred between the clinical experts and the child's score on the objective assessment.

The evaluative validity of the Melbourne Assessment was studied by following the rapid recovery phase of 11 children with an acquired cerebral insult. The tool was tested to determine sensitivity to obvious and expected change in the children's upper-limb function. The manual further details the Johnson et al. 1994 study that supports the sensitivity of the Melbourne Assessment to measure changes in function.

Extensive reliability studies were carried out on the 16-item format of the assessment between 1995 and 1997. High levels of intrarater and interrater reliability are reported in the manual, indicating that the Melbourne Assessment performs very reliably when used with the population for which it was intended.

PROCEDURE

Data for the Melbourne Assessment were collected over a 2-day period. The test was administered, as per the manual specification by an occupational therapist trained by the main author of the assessment. The test kit was used as originally sold. Each child was seated according to best ability. Positioning ranged from sitting freely on a stool (13 children), to a chair with back (two children), and a chair with back and armrest support (three children). Administration took between 15 and 35 minutes depending on the ability of the child. The manual specifies room set up, including video camera positions, and this was strictly adhered to. The videotape was later scored according to the manual stipulations and a raw score was calculated for each child.

Data for the PEDI were collected by completion of the questionnaire, by parents familiar with and informed about this assessment. Score sheets were collected from parents within 2 months of administration of the Melbourne Assessment due to logistical factors. All score sheets were reviewed by the author and parents were contacted to question inconsistencies in record completion. Three separate raw scores were calculated from the original score forms used for data collection. They were for the separate domain areas of self-care and mobility, and an overall cumulative score of the functional skill section.

STATISTICAL ANALYSIS

The total raw score from the Melbourne Assessment and three from the PEDI were analyzed using SPSS (version 10.0). The strength of correlation between performance on the Melbourne Assessment and self-care, mobility, and overall functional skills was calculated using the Spearman's rho with a two-tailed test of significance.

Table II: Raw score performance on Melbourne Assessment and PEDI (n=18)

	Mean	*SD*	*Min. score*	*Max. score*	*Median*
Melbourne Assessment	84.7	30.4	20	118	85.5
PEDI					
Self-care domain	45.2	21.1	5	72	49
Mobility domain	30.6	15.1	6	51	30
Total functional skills	119.3	48.8	31	186	127.5

Table III: Spearman's rho correlation coefficients cross tabulation (two-tailed significance) for Melbourne Assessment and PEDI

	PEDI		
	Self-care	*Mobility*	*Functional skills*
Melbourne Assessment	0.939	0.783	0.718
p	$p<0.0001$	$p<0.0001$	$p<0.001$

Results

Table II displays the descriptive data demonstrating the range of abilities of the children in the study. Performance on the Melbourne Assessment ranged from 20 to 118 of a possible 122, with a mean of 84.7 and standard deviation of 30.4. Performance on the self-care domain of the PEDI ranged from 5 to 72 of a possible 73, with a mean of 45.2 and standard deviation of 21.1. Performance on the mobility domain of the PEDI ranged from 6 to 51 of a possible 59, with a mean of 30.6 and standard deviation of 15.1. This table demonstrates the vast difference in skills of children participating in the study.

Table III displays the cross tabulation of the correlation between performance on the Melbourne Assessment and the self-care domain of the PEDI; the Melbourne Assessment and the mobility domain of the PEDI; and the Melbourne Assessment and the overall functional skills score on the PEDI. A very strong correlation was found between the Melbourne Assessment and the self-care domain (0.939) with a significance level of $p<0.0001$. A strong correlation was found between the Melbourne Assessment and the mobility domain (0.783) with a significance level of $p<0.0001$. A strong correlation was found between the Melbourne Assessment and the overall functional skills score (0.718) with a significance level of $p<0.001$.

Discussion

The results confirm that the Melbourne Assessment does measure upper-limb function as it relates to functional living skills. Although the sample size was small and the abilities of the children in the study were varied, a significant correlation was found when the data were analyzed. As expected, the strongest relation was between the Melbourne Assessment and a child's ability in self-care tasks such as toileting, dressing, and eating. Mobility was the second highest correlation, demonstrating the importance of upper-limb skill for functional mobility. Clinically, this relation promotes the importance of assessing

and providing interventions to the upper extremity, as well as the lower extremity, when aiming to improve mobility in children with CP. Finally, a strong correlation was found between the overall functional skill domain and the Melbourne Assessment. This correlation was expected to be the weakest because the overall score is composed of the self-care, mobility, and social function domains.

Another purpose of this study was to investigate the status of the Melbourne Assessment as a sound evaluative tool that can be used easily in the clinical setting. Criteria set by Rosenbaum et al. (1990) may be used to compare the psychometric status of this tool. The criteria are (1) clarity of purpose that has been validated; (2) clarity about what constructs are to be measured; (3) inclusion of items that are applicable to the population being measured; (4) reliability, and; (5) feasibility for use. Completion of this study allows comment on several of these factors.

Further studies are required to validate the purpose of the Melbourne Assessment as an evaluative tool. Studies must substantiate this tool's sensitivity to change over time and between the performances of several children. This study supports the construct validity of the Melbourne Assessment. This means that the test items and the criteria that are used to determine a score are pertinent to function in children with CP. Clinicians using this evaluation tool to detect or measure quality of upper-limb function, may be very confident that they are measuring movement that represents actual functional skills in daily living.

The Melbourne Assessment was easy to administer following review of the manual, adherence to directions for video recording, directions for item completion, and use of the test kit as provided. Evaluations were completed in a timely manner once the video recording was set up. A large room with adequate illumination is required for satisfactory video recording. Scoring is accurate and easy with the use of the video-recorded image, although the directions for videotaping must be strictly followed so that the later scoring may be accurate. Scoring of each child's performance required approximately as much time as administering each evaluation.

This study demonstrates that unilateral upper-limb movement can now be measured in an objective way that correlates with how the child actually performs functional daily living skills. The Melbourne Assessment is a useful tool to assist clinicians to measure upper-limb function in children with CP.

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References

Bach TM, Reddihough DS, Burgess G, Johnson LM, Byrt TA. (1994) Comparison of subjective and objective measures of movement performance in children with cerebral palsy. *Dev Med Child Neurol* **36:** 974–9.

Coster W, Haley SM. (1992) Conceptualization and measurement of disablement in infants and children. *Infants Young Child* **4:** 11–22.

Feldman AB, Haley SM, Coryell J. (1990) Concurrent and construct validity of the pediatric evaluation of disability inventory. *Phys Ther* **70:** 602–10.

Haley SM, Coster WJ, Ludlow LH, Haltiwanger JT, Andrellos PJ. (1992) *Pediatric Evaluation of Disability Inventory (PEDI).* Boston: New England Medical Center Hospitals.

Hinderer SR, Gupta S. (1996) Functional outcome measures to assess interventions for spasticity. *Arch Phys Med Rehabil* **77:** 1083–9.

Johnson LM, Randall MJ, Reddihough DS, Oke LE, Byrt TA, Bach TM. (1994) Development of a clinical assessment of quality of movement for unilateral upper-limb function. *Dev Med Child Neurol* **36:** 965–73.

Ketelaar M, Vermeer A, Helders PJ. (1998) Functional motor abilities of children with cerebral palsy: a systematic literature review of assessment measures. *Clin Rehabil* **12:** 369–80.

Nichols DS, Case-Smith J. (1996) Reliability and validity of the pediatric evaluation of disability inventory. *Pediatr Phys Ther* **8:** 15–24.

Randall M, Johnson L, Reddihough D. (1999) *The Melbourne Assessment of Unilateral Upper Limb Function: Test Administration Manual.* Melbourne, Australia: Royal Children's Hospital.

Reddihough D, Court JM, Evans O, Hudson IL. (1987) Objective assessment of limb movement in children with cerebral palsy. *Aust Paediatr J* **23:** 289–91.

Reddihough D, Bach T, Burgess G, Oke L, Hudson I. (1990) Objective test of the quality of motor function in children with cerebral palsy. *Dev Med Child Neurol* **32:** 902–9.

Reddihough D, Bach T, Burgess G, Oke L, Hudson I. (1991) Comparison of subjective and objective measures of movement performance of children with cerebral palsy: preliminary study. *Dev Med Child Neurol* **33:** 578–84.

Reid DT, Boschen K, Wright V. (1993) Critique of the pediatric evaluation of disability inventory. *Phys Occup Ther Pediatr* **13:** 57–87.

Rosenbaum PL, Russell DJ, Cadman DT, Gowland C, Jarvis S, Hardy S. (1990) Issues in measuring change in motor function in children with cerebral palsy: a special communication. *Phys Ther* **70:** 125–31.

Ziviani J, Wright S. (1995) Paediatric evaluation of disability inventory – review and application. *New Zeal J Occup Ther* **46:** 15–18.

AUTHOR'S NOTE

This study was conducted in partial fulfilment of a Master of Science, in the school of Occupational Therapy at the University of Indianapolis, Indiana, USA.

Appendix I: Melbourne Assessment of Unilateral Upper Limb Function Score Sheet (Randall et al. 1999)

Name:	**Limb** (right/left):
Date of birth:	**Contractures:**
Date of assessment:	**Splinting/upsuit etc:** (describe)
Diagnosis:	**Seating:** (inc. supportive straps/pads)
Assessor:	
% score:	**Marked position:** (variation to)

							Comments
Item 1	**Reach forwards**						
1.1	Range of movement	0	1	2	3	–	
1.2	Target accuracy	0	1	2	3	–	
1.3	Fluency	0	1	2	3	–	
Item 2	**Reach forwards to an elevated position**						
2.1	Range of movement	0	1	2	3	–	
2.2	Target accuracy	0	1	2	3	–	
2.3	Fluency	0	1	2	3	–	
Item 3	**Reach sideways to an elevated position**						
3.1	Range of movement	0	1	2	3	–	
3.2	Target accuracy	0	1	2	3	–	
3.3	Fluency	0	1	2	3	–	
Item 4	**Grasp of crayon**	0	1	2	3	4	
Item 5	**Drawing grasp**	0	1	2	3	–	
Item 6	**Release of crayon**						
6.1	Range of movement	0	1	2	3	–	
6.2	Quality of movement	0	1	2	3	–	
6.3	Accuracy of release	0	1	2	3	4	
Item 7	**Grasp of pellet**	0	1	2	3	4	
Item 8	**Release of pellet**						
8.1	Range of movement	0	1	2	3	–	
8.2	Quality of movement	0	1	2	3	–	
8.3	Accuracy of release	0	1	2	3	4	
Item 9	**Manipulation**						
9.1	Finger dexterity	0	1	2	3	4	
9.2	Fluency	0	1	2	3	–	
Item 10	**Pointing**						
10.1	Red square	0	1	2	3	4	
10.2	Green square	0	1	2	3	4	
10.3	Yellow square	0	1	2	3	4	
10.4	Blue square	0	1	2	3	4	
Item 11	**Reach to brush from forehead to back of neck**						
11.1	Range of movement	0	1	2	3	4	
11.2	Fluency	0	1	2	3	–	
Item 12	**Palm to bottom**						
12.1	Range of movement	0	1	2	3	–	
12.2	Fluency	0	1	2	3	–	
Item 13	**Pronation/supination**	0	1	2	3	4	
Item 14	**Hand to hand transfer**	0	1	2	3	4	
Item 15	**Reach to opposite shoulder**						
15.1	Range of movement	0	1	2	3	–	
15.2	Target accuracy	0	1	2	3	–	
15.3	Fluency	0	1	2	3	–	
Item 16	**Hand to mouth and down**						
16.1	Range of movement	0	1	2	3	–	
16.2	Target accuracy	0	1	2	3	–	
16.3	Fluency	0	1	2	3	–	
16.4	Speed	0	1	2	–	–	

Total raw score:
Maximum total score (122):

% Score: $\left(\frac{\text{raw score}}{\text{maximum total score}} \times 100\right)$

Appendix II: Scoring Example

Item 3: Reach sideways to elevated position

Sub-skill 1: Range of movement
Pause the video on the initial point of sustained contact with the target and score at this point.

Scoring criteria

3 Required range of movement:
- some trunk displacement and head righting if required after range of movement listed below has been achieved
- shoulder abduction within 80°–100° range
- neutral shoulder rotation
- elbow extension within 135°–180° range
- forearm pronated 60°–90°
- wrist in neutral or extension.

2 Compensatory movements and/or abnormal movement patterns involving one or two joints, observed at the:
- trunk
- neck
- shoulder
- elbow
- wrist.

1 Compensatory movements and/or abnormal movement patterns involving three or more joints, as observed in 2 above.

0 Insufficient range of movement to complete task.

Comments: note abnormal movement patterns or compensatory movements observed and at which joints they occur.

Sub-skill 2: Target accuracy
Pause the video on the initial point of sustained contact with the target and score at this point.

If the child touches two of the below criteria simultaneously score at the lowest level.

Scoring criteria

3 Reaches smiley face on initial point of sustained contact.

2 Reaches coloured circle on initial point of sustained contact.

1 Reaches switch on initial point of sustained contact.

0 Does not reach switch

Comments: note if two or more areas of the switch are touched simultaneously.

Sub-skill 3: Fluency
View the movement of reaching at normal speed. Score the fluency of any attempted movement even if the movement did not result in successful contact with the switch.

Scoring criteria

3 Smoothly coordinated movement.

2 Barely noticeable jerkiness or tremor present with task still easily achieved.

1 Clearly noticeable jerkiness or tremor present, requiring increased effort to achieve task.

0 Unable to achieve task due to excessive jerkiness or tremor preventing required contact.

Comments: note at which point in the reach movement the jerkiness or tremor is apparent.