Establishing Validity of a Modified Melbourne Assessment for Children Ages 2 to 4 Years

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BACKGROUND. The Melbourne Assessment of Unilateral Upper Limb Function is a valid tool for measuring quality of upper-limb movement in children ages 5 to 15 with cerebral palsy. This study presents the first phase in establishing the validity of a modified version of the assessment for children ages 2 to 4.

OBJECTIVE. We sought to determine whether children without neurological impairment scored within the top 5% on the modified assessment, to investigate compliance with test demands, and to investigate the relationship between the modified tool and the Quality of Upper Extremity Skills Test.

METHOD. The test was modified and administered to 32 children without neurological impairment ages 2 to 4.

RESULTS. All children ages 2.5 to 4 scored as expected and were compliant with test demands.

CONCLUSION. The Modified Melbourne Assessment may be used with children ages 2.5 to 4 without neurological impairment. Investigation with children with neurological impairment is now indicated.


This article reports the first stage of a study aiming to extend the application and to establish the validity of the Melbourne Assessment of Unilateral Upper Limb Function (Randall, Johnson, & Reddihough, 1999) for use with children ages 2 to 4 who have a neurological impairment. The assessment, known as the Melbourne Assessment, was initially developed as a valid and reliable measure to objectively evaluate quality of upper-limb movement in children ages 5 to 15 with cerebral palsy (Johnson et al., 1994; Randall, Carlin, Chondros, & Reddihough, 2001; Randall et al., 1999). The assessment measures how a child moves his or her upper limb while performing test items that simulate occupation-based tasks such as self-feeding, reaching to brush one’s hair, or turning one’s hand over to stabilize or carry a bowl or plate. For clinicians aiming to optimize a child’s performance of these tasks, the Melbourne Assessment provides a framework from which they can identify the specific movement components with which the child is experiencing difficulty. The 16 test items include the upper-limb movement components of reach, grasp, manipulation, and release of objects needed for common daily living tasks. Performances on test items are scored for range of movement, accuracy, fluency, and level of grasp and release. Left and right upper limbs are assessed separately (if required), and the assessment has no age bias or developmental increment for children ages 5 to 15 (Randall et al., 1999).

Although the Melbourne Assessment has already been included as an outcome measure in several research studies (Boyd et al., 2003; Duncan & Randall, 2000; Ozer, Cheshar, & Scheker, 2006; Wallen, O’Flaherty, & Waugh, 2007), the lower age limit of 5 years has limited its application across a wider age range. No single
outcome measures quality of upper-limb movement across the full age range of childhood and adolescence. Given the clinical and research benefits in having a common measure available, we deemed it important to extend and establish the validity of a modified version of the Melbourne Assessment to include children as young as 2 years old.

The measurement of quality of upper-limb movement is clinically important for children younger than 5 and for children ages 5 to 15 on whom the Melbourne Assessment is currently validated. The established focus of service providers on early intervention and the recent introduction of pharmaceutical interventions such as botulinum toxin A (Hoare & Imms, 2004) with this younger age group highlights the need for clinicians to have access to valid and reliable outcome measures specific to, or inclusive of, children in this younger age group. For example, botulinum toxin A specifically acts to reduce spasticity and increase a child’s range of movement and motor control when performing activities of daily living. Thus, clinicians need outcomes that measure the aspects of impairment and quality of movement targeted by these new interventions. Scoring criteria included on the Melbourne Assessment address children’s range of movement abilities while they are performing actions related to tasks of daily living, for example, range of movement while reaching to take a food item to their mouth.

One concern for clinicians when assessing any young child is the child’s ability to comply with test demands and perform the skills assessed by the tool. These issues often determine the lower age level at which children may be formally assessed with a specific tool. Referring to both the literature on child development (Bayley, 1969; Erhardt, 1982; Exner, 1992; Pehoski, 1995) and clinicians’ experiences of children’s compliance with therapy and test demands, we determined that 2 years of age would be an appropriate lower age level at which children might be expected to comply with the instructions and demands of a simple test of upper-limb movement.

An extensive literature review yielded 13 measures of upper-limb abilities in children (see Table 1), but only the Quality of Upper Extremity Skills Test (QUEST; DeMatteo, Law, Russell, Pollock, & Walter, 1992) and the Melbourne Assessment (Randall et al., 1999) measure quality of upper-limb movements in children with neurological impairment. The age range of children for whom the QUEST has been validated is 18 months to 8 years. The literature review therefore confirmed the absence of a single measure of quality of upper-limb movement for children with neurological impairment that spanned the broad age range of 2 years to adolescence. Because the Melbourne Assessment and the QUEST were the only two quality-of-movement measures located, we briefly review both.

Pediatric Measures of Quality of Upper-Limb Movement

Melbourne Assessment

The Melbourne Assessment is a criterion-referenced measure of quality of unilateral upper-limb movement in children ages 5 to 15 with cerebral palsy. It was developed using theoretical and developmental literature and clinical knowledge of the components of movement and tasks with which children with neurological impairment commonly have difficulty. Test items relate to functional tasks such as reaching to the mouth to self-feed and to the head for hair grooming. For each test item, the most important components of the observed movement are scored using specific criteria.

Clinically, the Melbourne Assessment identifies the underlying components of movement, such as range of movement or fluency, with which a child is experiencing difficulty when performing typical upper-limb tasks. Identification of the specific difficulties experienced is critical for clinicians to be able to target their interventions to improve, or compensate for, the component deficit in occupation-based tasks. For example, if a child was observed to score low on all range-of-movement subitems, therapists would be able to focus their intervention on improving the child’s range of movement within tasks relevant to the child and then measure the effect of their intervention. In research applications, the Melbourne Assessment quantifies a child’s quality of movement and thus provides researchers with a valid and reliable tool for empirically testing a treatment’s effectiveness.

Studies to date have indicated that the Melbourne Assessment is a reliable and valid measure of quality of upper-limb movement for children ages 5 to 15 with neurological impairment (Bourke-Taylor, 2003, 2004; Corn et al., 2003; Randall et al., 1999, 2001). Randall et al. (2001) found the Melbourne Assessment to have excellent reliability for total scores, with all reliability estimates being between .96 and .98 (Cronbach’s alpha and intra- and interrater reliability for both same tape and repeat tape scoring). These studies involved tapes of 20 children individually scored on repeat occasions by 16 therapists. A further study by Bourke-Taylor (2003) involved 18 children with cerebral palsy who were assessed on both the Melbourne Assessment and the Pediatric Evaluation of Disability Inventory (PEDI; Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992). The PEI measures a child’s functional abilities and level of caregiver assistance needed in self-care, mobility, and social functioning tasks. When the children’s scores on the two assessments were analyzed, a strong correlation was found between scores on the Melbourne Assessment and those on the self-care domain of the PEI (r = .94), and a moderate to strong...
correlation was found between scores on the Melbourne Assessment and those on the mobility domain \( r = .78 \). Thus, this study’s findings support the construct validity of the Melbourne Assessment as a measure of quality of upper-limb movement as related to a child’s everyday activities in children ages 5 to 15.

**QUEST**

The QUEST is a measure of quality of bilateral upper-limb movements that has been developed specifically for children ages 18 months to 8 years with upper-limb spasticity. The QUEST was developed using neurodevelopmental theories and measures components of hand function and quality of upper-limb movement.

Studies undertaken in the QUEST’s development found it to be a reliable and valid measure of quality of upper-extremity movement for children with upper-limb spasticity (DeMatteo et al., 1992). DeMatteo et al. (1992) examined the QUEST in three studies and reported that it had excellent interrater reliability. Intra-class correlation coefficients for total scores across two and three raters were calculated as .96 and .90, respectively. The QUEST also had very high test–retest reliability (intra-class correlation coefficient = .95) when 17 stable children were assessed; however, DeMatteo et al. (1992) did not specify the number of raters involved and the time period between the second scoring of the tapes. Finally, a study of the QUEST’s concurrent criterion-related validity with the Peabody Developmental Motor Scales–Fine Motor component reported moderate to high correlations \( r = .58 – .84 \) between 71 children’s scores on the two tools (DeMatteo et al., 1992). These findings support the QUEST’s validity as a measure of upper-limb skills in children ages 18 months to 8 years.

When one compares the attributes of the two assessments, the Melbourne Assessment has a wider upper age range of 5 to 15 years and increased scale resolution (4–5 points), and it includes functionally related test items. In addition, we anticipated that it would be relatively simple to adapt the Melbourne Assessment test items for children ages 2 to 4. For these reasons, we decided to develop and validate a modified version of the Melbourne Assessment to include children as young as 2 years old. To establish evidence for the use of a modified version of the tool with younger children, it was beneficial to compare its clinical utility with a tool already validated for children 2 to 4 years old. Because the QUEST was validated for use with children in this age range, we deemed it appropriate to include the QUEST as a comparative measure in this study.

The focus of this project therefore was to establish the face and content validity of a modified version of the Melbourne Assessment for use with 2- to 4-year-old children without neurological impairment. Project aims were as follows:

- To develop an adapted assessment protocol for the Melbourne Assessment (the Modified Melbourne Assessment) that was appropriate to the comprehension, attention, and motor skill capacities of children ages 2 to 4;
- To determine whether a sample of 2- to 4-year-old children without neurological impairment could achieve near-maximum scores on the Modified Melbourne Assessment protocol consistent with performance expectations on the current Melbourne Assessment (i.e., achieving scores greater than 95%);
• To compare children’s compliance with the task and time demands of the Modified Melbourne Assessment with their compliance with those of the QUEST, a valid and reliable measure developed for younger children (the level of children’s compliance with the demands of the modified assessment is an important consideration for its potential use in clinical and research applications); and
• To investigate the relationship between performance scores on the Modified Melbourne Assessment and the QUEST for 2- to 4-year-old children without neurological impairment.

Method

Developing Face and Content Validity of the Melbourne Assessment for Use With Children Ages 2 to 4

The published version of the Melbourne Assessment was unlikely to be valid for younger children without modification because of the influence of motor development on fine motor skills in children younger than 5. In this version of the assessment, all the assessed motor elements are expected to be present and mature by 5 years of age in a typical child who has no neurological impairment (Johnson et al., 1994).

To extend the test to include children 2 to 4 years old, we anticipated that a few test items would require revision and adaptation. To ensure a full appraisal of the demands of the test for children ages 2 to 4, we undertook a comprehensive review of the Melbourne Assessment.

Initially, Melinda Randall and Christine Imms reviewed the administration guidelines, test items, and scoring criteria for the original Melbourne Assessment. They used their knowledge of child development and clinical pediatric experiences and reviewed the literature and assessments of normal hand development to provide evidence to guide their initial modifications of test and scoring procedures. From this initial process, they identified three items—Item 5, drawing grasp; Item 9, manipulation; and Item 10, pointing—as requiring changes to accommodate the developmental progression of motor skills and ability of children ages 2 to 4 to attend to and follow instructions (the Appendix shows an edited scoresheet listing a sample of test items and subitems). We then used the following two-phase process to ensure the development of comprehensive and appropriate modifications.

Phase 1: Modifications to Identified Test Items. We developed changes to Items 5, 9, and 10 on the basis of clinical reasoning and knowledge of developmental increments in skill and movement established in the literature (Erhardt, 1982; Exner, 1992; Folio & Fewell, 1983; Pehoski, 1995). We documented changes to the scoring guidelines for Items 5 and 9 to accommodate the maturational changes in drawing grasp (Item 5) and in-hand manipulation (Item 9) skills at the 2-, 3-, and 4-year-old age level. For Item 5 (drawing grasp), we did not expect 3- and 4-year-old children without impairment to demonstrate a mature dynamic tripod grasp, which achieves a full score of 3 points. For children ages 3 to 4, the expected maximum score on this item is 2 points; for children age 2, the expected maximum score is 1 point. For Item 9 (in-hand manipulation), 3- and 4-year-old children without impairment are only expected to score a maximum of 2 or 3 points out of a possible 4 points for the finger dexterity subskill. Two-year-old children without impairment are expected to score 1 point. Thus, the overall totals for the drawing grasp and finger dexterity subskills and the total maximum score for the full assessment are reduced depending on the age of the child performing the assessment.

There will be exceptions to these developmental expectations, and if younger children perform at a higher level than expected for their age on either of these two items, they receive the higher score, reflecting their performance.

We developed modified equipment for Item 9, manipulation, and Item 10, pointing. The modified equipment consisted of the addition of a simple colored picture of a dog, car, and teddy bear on three faces of the cube used in Item 9 and the placement of the same three pictures and a fourth picture of a ball in the center of each of the colored squares in Item 10. The addition of these simple visual stimuli facilitated the use of more explicit instructions to the younger children to assist them in performing the required upper-limb movements. For example, in Item 10, the assessor can say to the younger child “Point to the dog” or “Point to the car.” These instructions are easier for the child than the original instruction, “Point to the black center of the red rectangle.”

Phase 2: Implementation of a Three-Round Iterative Survey to Establish the Modified Melbourne Assessment for Use With Children Ages 2 to 4. We used a three-round survey technique (Portney & Watkins, 2000) involving a panel of eight occupational therapists who were familiar with the Melbourne Assessment to review it for use with younger children. Seven of the eight therapists surveyed had at least 8 years’ experience working with children with movement disorders. Years of pediatric experience ranged from 5 to 24 years, with a median of 16.0 years and an interquartile range of 9.75 to 19.25 years.

We distributed an initial draft of the modifications to three expert clinicians from the Occupational Therapy Department of the Royal Children’s Hospital, Melbourne, Victoria, Australia. After feedback from these clinicians, we identified additional items requiring modification. Further changes were made to the test administration guidelines, and
we then distributed Draft 2 to two pediatric instructors from the School of Occupational Therapy, La Trobe University, Melbourne. Once again, feedback identified the need for further changes; once these changes were made, we distributed Draft 3 to three pediatric clinicians in New South Wales who had extensive experience in using the Melbourne Assessment in research. An additional final review and feedback were sought from an experienced pediatric speech pathologist regarding the language used and level of instruction and demonstration provided when administering the test items. Using this cyclic process of expert review and modification, we developed the final adapted assessment protocol, known as the Modified Melbourne Assessment.

Establishing Test Utility and Ongoing Content Validity of the Modified Melbourne Assessment for Children Without Neurological Impairment Ages 2 to 4

To determine whether the Modified Melbourne Assessment could be successfully administered to children ages 2 to 4, we implemented a trial of the modified assessment with children of this age without neurological impairment. This trial aimed to establish whether (1) all children scored within the expected range, that is, above 95%; (2) all children could successfully comply with the assessment’s task and time demands; and (3) there was a positive relationship between the child’s performances on the Modified Melbourne Assessment and the QUEST.

All children in this study were expected to achieve full or nearly full scores on the Modified Melbourne Assessment because it had been modified for use with children ages 2 to 4 and the children did not have a neurological impairment. As with the original Melbourne Assessment, the modified version was designed so that full scores could be readily achieved by children without neurological impairment. We set a criterion level of 95% or greater for children’s expected scores on the Modified Melbourne Assessment to allow for some margin of error, as classical test theory assumes that an observed score consists of a “true” score and an “error” score (Streiner & Norman, 1995). In the absence of a known standard error of measurement for the Melbourne Assessment and given our clinical understanding of the variation in typical movements that could be expected from a group of children without impairment, we considered a 5% error score acceptable for the purpose of determining whether this group of children without impairment could achieve maximum scores on the modified tool.

We evaluated children’s performances during testing on the QUEST to provide descriptive information from which to compare aspects of the Modified Melbourne Assessment when used with children ages 2 to 4. Aspects of the test that we considered included children’s compliance and cooperation with test items and instructions, time taken to administer and score the assessment, and ease of use of the modified test by therapists. QUEST scores also provided a means of independently assessing each child’s quality of upper-limb movement. This allowed comparison of scores on the Modified Melbourne Assessment with scores on a tool that was developed and had empirical support for its use with children ages 2 to 4. We expected no gender bias in children’s scores on either test.

Approval for the study was received from the Ethics in Human Research Committee at the Royal Children’s Hospital, Parkville, and the La Trobe University Human Ethics Committee, Melbourne. Recommendations from both ethical committees were adhered to throughout the study.

Participants

Ten children (5 girls, 5 boys) were recruited to each of the three required age groups, that is, (1) 24 to 35 months, (2) 36 to 47 months, and (3) 48 to 59 months. All children attended the Child Care Centre of the Royal Children’s Hospital, Melbourne, and were randomly identified from the attendance list. They had no known neurological deficits, and we obtained written consent to participate in the study for all children. Two children ages 24 to 29 months (1 girl, 1 boy) were unable to complete the assessment tasks because of poor attention to and compliance with test instructions; thus, we randomly recruited an additional girl and boy ages 24 to 35 months. The final number of children recruited into the study was 32; however, data are available only for the 30 children who completed the assessments.

Outcome Measures

Modified Melbourne Assessment. We developed the Modified Melbourne Assessment protocol for use with children ages 2 to 4 years as described previously. As in the published version of the tool, the upper-limb movement components of range of movement, target accuracy, fluency, and level of grasp and release are scored across the 16 test items. We included minimal changes to scoring of 2 test items to accommodate the maturational changes expected in children in this age range. All 37 subskills are scored using the existing 3-, 4-, or 5-point scoring scale. Raw scores for each child are summed and converted to a percentage of their total possible score. The total possible score is adjusted for items on which a full score is not expected because of the child’s age or for items that the child does not perform.

QUEST. On the QUEST, a child’s upper-limb movements are scored in four domains. The dissociated movement domain scores the child’s ability to isolate movements at the shoulder, elbow, and wrist and move each joint through its full range of movement. The grasp domain scores
the developmental level of the child’s grasp of a cube, pellet, and crayon for drawing; the weight-bearing domain scores the child’s ability to prop and support him- or herself in forward, sideward, and backward planes; and the protective extension domain scores the presence of protective extension responses in a forward, sideward, and backward direction. A 2-point scale is used to score the presence or absence of specific movements for each upper limb on test items in each domain. In the dissociated movements domain, the 2-point scale is used to score the range of a child’s movements as being less than or greater than half of the full range of movement expected for a nonimpaired child. Raw scores are summed for each domain and converted to a standardized score out of 100. Calculations of standardized scores adjust for items that the child does not perform. The four standardized scores are then averaged to obtain an overall total score.

Procedure
Each child was videotaped while being assessed with both the Modified Melbourne Assessment and the QUEST. We randomly alternated the order of assessment to accommodate for the potential effects of fatigue during the assessment process. Children were assessed in an office area within the child care center. Either the child’s parent or a familiar child care worker attended the assessment session with each child. Melinda Randall administered both assessments to each child, and an assistant operated the video camera to record each child’s test performance. Hand preference was established by placing a crayon and paper in the child’s midline and asking the child to do a drawing before commencing the assessment. The hand used spontaneously by the child to hold the crayon while drawing was the hand assessed. Time taken to administer each of the assessments was recorded at the time of assessment. Resulting videotaped assessments were subsequently scored by Randall, and the time taken to score each of the assessments was recorded.

Statistical Analyses
We examined the participants’ percentage scores on the Modified Melbourne Assessment and total scores on the QUEST descriptively, using the Statistical Package for the Social Sciences Version 11.5 (SPSS Inc., Chicago). We used nonparametric statistics in comparative analyses for scores on the Modified Melbourne Assessment because the data set was not normally distributed, and we calculated a chi-square statistic to determine whether the distribution of observed test scores differed from expected test scores. Children’s compliance with the demands of the Modified Melbourne Assessment, including their ability to perform test items and follow test instructions and the time taken to administer and score the assessment, were also evaluated descriptively. We used a scatter plot to inspect the children’s performance scores on the Modified Melbourne Assessment and the QUEST and to examine children’s scores on each assessment comparative to their age in months.

Results
Total Percentage Scores Achieved on the Modified Melbourne Assessment
The range of percentage scores, including the median and interquartile values, on the Modified Melbourne Assessment for each age group of children is shown in Figure 1. The median score for each age group was above 99%. Figure 2 shows that 10 of the 30 children who completed the assessment scored 100% on the Modified Melbourne Assessment, and a further 19 children scored 95% or more, giving a total of 29 children (i.e., 96.6% of the participants) who scored 95% or above on the assessment. There was no significant difference between the observed frequency and the expected frequency of children scoring above 95% on the Modified Melbourne Assessment, $\chi^2 [1, 30] = 0.03, p = .68$.

QUEST Total Scores
The range of total scores, including the median and interquartile values, on the QUEST for each age group of children is also displayed in Figure 1. The children’s median scores for each age were lower on the QUEST than on the Modified Melbourne Assessment and ranged from 94.22 for 2-year-old children to 96.72 and 95.83 for 3- and 4-year-old children, respectively. Figure 2 shows that there was an

![Figure 1. Boxplot of range of total scores on the Modified Melbourne Assessment (MMA) and the Quality of Upper Extremity Skills Test (QUEST) for each age group (n = 10 at each age group). The same scale is used for performance scores on both assessments; however, scores on the Modified Melbourne Assessment are percentage scores, and scores on the QUEST are total scores. Circles indicate outlier scores.](image-url)
increase in the number of children who had a total score greater than 95 out of 100 at each ascending age level. That is, although only 40% (4 of 10) of the 2-year-old children assessed on the QUEST scored 95 or higher, 6 and 8 of the 10 children ages 3 and 4, respectively, scored 95 or higher. Eighteen children (i.e., 60% of participants) scored 95 or higher on the QUEST.

**Children’s Compliance With Task and Time Demands of the Modified Melbourne Assessment**

**Children’s General Compliance With Test Demands.** Melinda Randall rated compliance with the demands of both assessments for each of the 32 children on a cooperativeness rating scale, as used in the QUEST (DeMatteo et al., 1992). Children’s level of cooperativeness was rated as very cooperative, somewhat cooperative, or not cooperative (see Table 2). Only 3 of the 32 children assessed were rated on both tests as not cooperative. These 3 children were in the youngest age group (between 24 to 29 months old). Of these 3 children, 2 were unable to attend adequately to the instructions to complete either assessment; thus, we recruited 2 additional children to the study for this age group, as noted earlier. All remaining children, with ages ranging from 29 to 47 months, cooperated sufficiently to enable completion of both assessments.

**Table 2. Level of Cooperativeness for Each Age Group**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Very Cooperative</th>
<th>Somewhat Cooperative</th>
<th>Not Cooperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 years</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3 years</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 years</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Gender: 5 girls, 1 boy 3 boys 2 boys, 1 girl

<table>
<thead>
<tr>
<th>Age range</th>
<th>29–35 months</th>
<th>30–35 months</th>
<th>24–29 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>26</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

**Note.** Each child scored the same for level of cooperation on the Modified Melbourne Assessment and the Quality of Upper Extremity Skills Test.

**Children’s Ability to Perform Test Items and Follow Test Instructions.** The 30 children who completed the assessments displayed a few minor difficulties in complying with instructions and completing test items. On the Modified Melbourne Assessment, 3 of the 2-year-old children consistently performed test items with reduced attention to accurately completing movements. For example, on Item 10, pointing, they performed the movement quickly but were careless in accurately touching their index finger to the pictures. On Item 4, grasp of crayon, they snatched the crayon into the palm of their hand rather than picking it up using a radial digital grasp as the test required. Four of the 2- and 3-year-old children had difficulty on three other items: Item 13, pronation/supination, on which all 4 children had difficulty understanding the instruction to turn their hand over; Item 14, hand-to-hand transfer, on which 2 children displayed reduced spontaneity of grasp and release when passing the wand between the hands, such that their performance looked like a two-stage transfer rather than an adept one-stage transfer; and Item 15, reach to opposite shoulder, on which 3 children had difficulty with the concept of crossing their midline to touch their hand to their opposite shoulder and touched their ipsilateral shoulder instead, even when tapped on the desired shoulder.

In relation to the QUEST, there were three items on which it was difficult to elicit the appropriate movement for children across all ages assessed. In the Dissociated Movements section, two items that were difficult to elicit were the wrist and finger items of “Wrist Flexion—with forearm in complete supination” and “Independent Finger Wigging.” All of the children had difficulty with flexing their wrist while holding their forearm in a supinated position, and many children could not demonstrate isolated independent finger movements but would move several fingers at the same time. In the Protective Extension section, it was difficult to elicit the optimal posture for the “Backward extension” item of fully extended elbows in many children; thus, their scores were reduced.

**Test Time.** Melinda Randall also recorded time taken to administer and score each test at the time of administering and scoring each child’s assessment. There were minimal time differences between using the Modified Melbourne Assessment and the QUEST, as reported in Table 3. The mean time taken to administer the Modified Melbourne Assessment and the QUEST was 10.7 min (SD = ±2.8) and 8.8 min (SD = ±2.1), respectively. Overall mean scoring time for the Modified Melbourne Assessment was 16.7 min (SD = ±7.1); for the QUEST, it was 15.1 min (SD = ±5.5). We do not consider these differences to be clinically important.

**Relationship Between Scores on the Modified Melbourne Assessment and the QUEST.** The relationship between the
Table 3. Time to Administer and Score the Modified Melbourne Assessment (MMA) and Quality of Upper Extremity Skills Test (QUEST) for Each Age Group

<table>
<thead>
<tr>
<th>Component/Test</th>
<th>4 years</th>
<th>3 years</th>
<th>2 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Administration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMA</td>
<td>10.3</td>
<td>9.7</td>
<td>12</td>
<td>10.7</td>
</tr>
<tr>
<td>QUEST</td>
<td>8.1</td>
<td>9.0</td>
<td>9.2</td>
<td>8.8</td>
</tr>
<tr>
<td><strong>Scoring</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMA</td>
<td>13.9</td>
<td>17</td>
<td>19.2</td>
<td>16.7</td>
</tr>
<tr>
<td>Quest</td>
<td>11.1</td>
<td>17</td>
<td>17.3</td>
<td>15.1</td>
</tr>
</tbody>
</table>

Children’s percentage scores on the Modified Melbourne Assessment and their total scores on the QUEST is shown in Figure 3. All of the children, with the exception of the youngest child, age 25 months, scored at the top end of the scale for both assessments. This younger child scored 89% on the Modified Melbourne Assessment and 89 on the QUEST. Figure 4 shows the spread of children’s scores on the Modified Melbourne Assessment and the QUEST relative to their age in months. Inspection of the scatter plots reveals the reduced variability in the children’s score on the Modified Melbourne Assessment compared with the QUEST. Both the QUEST and the Modified Melbourne Assessment show little relationship between age and scores.

Discussion

It is vital that health professionals have access to measures that evaluate quality of movement for children with cerebral palsy across a wide age range of childhood, from very young children to adolescents (Boyce et al., 1991). The results of this initial study to extend the Melbourne Assessment to include children as young as 2 years provides encouraging evidence that this assessment can be developed to be such a tool. In this study, 2.5- to 4-year-old children without neurological impairment performed as expected on the Modified Melbourne Assessment, that is, they achieved maximum scores on the modified tool. The one child who scored below 95% on the modified assessment was the youngest child in

Figure 3. Scatter plot of Modified Melbourne Assessment (MMA) percentage scores with Quality of Upper Extremity Skills Test (QUEST) total scores.

Figure 4. A: Scatter plot of Modified Melbourne Assessment (MMA) percentage scores with age in months; B: Quality of Upper Extremity Skills Test (QUEST) total scores with age in months.
the study, age 25 months, and her score was reduced on both assessments because of her difficulty in attending to and following instructions.

It is important to mention that, although only 60% of children had a total score higher than 95 on the QUEST, the QUEST contains several items in which level of scoring is influenced by developmental increments. Items such as “grasp of pencil or crayon,” “independent finger wiggling,” and “independent thumb movement” would be expected to show variation in possible maximum scores achieved by children across the ages of 2, 3, and 4, which would influence the total score achieved by these younger nonimpaired children. Thus, we would not expect all children in this study to achieve full or nearly full scores on the QUEST as we expected them to do on the Modified Melbourne Assessment.

Investigation of the clinical utility of the Modified Melbourne Assessment involved comparison of children’s compliance with test demands, children’s ability to perform test items and follow test instructions, and time taken to administer and score the test relative to the QUEST. The Modified Melbourne Assessment could be successfully administered to children without neurological impairment ages 30 months and older. However, three of the four children ages 24 to 29 months did experience difficulties in attending to and following test instructions for both assessments. This leads us to recommend further investigation of the utility and validity of both assessments for children younger than 30 months. Both assessments contained several items that children ages 2 to 4 had difficulty achieving. It is unclear whether these difficulties reflected children’s motor maturity or their personality. Children’s performances were also reduced by their diminished understanding or performance of the movement required of them for two items on the QUEST. There was little or no difference in total time taken to use the Modified Melbourne Assessment compared with the QUEST.

We investigated the relationship between children’s scores on both assessments using visual inspection of scatter plots as recommended by Portney and Watkins (2000). We did not calculate a correlation coefficient because of the restricted range of scores in this typical sample of children (i.e., all children performed near the top end of the scale on both tests). We will reexamine the relationship between scores on the Modified Melbourne Assessment and the QUEST in a study investigating the use of the Modified Melbourne Assessment with children ages 2 to 4 years with neurological impairments. We would expect these children to present with a greater range of scores on both assessments; thus, a less restricted estimate of the correlation between these assessments may be found.

Clinicians and researchers need valid, reliable, and responsive clinical measures for children with cerebral palsy so that studies of treatment effectiveness can be accurately undertaken (Parette & Hourcade, 1984). At this time, although there are two tools available that measure quality of upper-limb movement in children with cerebral palsy, neither tool assesses children across a wide age range. The benefits to clinicians and researchers in having a single tool that spans the age range from very young children to adolescents has led to this investigation to review and test the Melbourne Assessment for use with younger children. Our intention is for the original administration and scoring instructions for the Melbourne Assessment to be used with children with neurological impairments ages 5 to 15 years. The second stage of this study will establish whether the Modified Melbourne Assessment is a valid tool for use with younger children with neurological impairments ages 2 to 4 years.

Limitations

Because there were only four children in the youngest age level of 24 to 29 months, the ability of children in this age range to be assessed by either measure remains unclear. Further study of the utility and validity of both assessments for children younger than 30 months is required. The scoring of the tests was undertaken by a single scorer who consecutively scored both assessments for each child, which may have introduced bias into the score results. The data may benefit from single assessments for each child that are scored in a random order by a scorer not involved in the administration of the assessments and who does not know the children.

Conclusion

This study to establish the face and content validity of the Modified Melbourne Assessment for measuring quality of upper-limb movement in children ages 2 to 4 has shown that the modified assessment can be used with confidence in children older than 30 months. In comparison, three of the 24- to 29-month-old children had difficulty complying with the demands of the test; either they could not be assessed on the modified tool or they showed lower-than-expected scores. Further validation of the modified tool with children 24 to 29 months of age is required.

As a second stage, we have begun an investigation of the use of the Modified Melbourne Assessment with 30 children who are 2 to 4 years old who have neurological impairments. If the validity of the Modified Melbourne Assessment for 30-month-old to 4-year-old children with neurological impairment is established, it, coupled with the original version
of the tool, will provide clinicians and researchers with a single-outcome measure of quality of upper-limb movement for children with neurological impairment that can be used across the broad age range of 30 months to 15 years.

Acknowledgments

We thank the staff and participating children and families from the Royal Children’s Hospital Child Care Centre, Melbourne, Victoria, Australia, who made the trial of the Modified Melbourne Assessment possible. Our appreciation also to the experienced clinicians from Victoria and N.S.W. who reviewed the Melbourne Assessment. This project was supported by a grant from the Murdoch Children’s Research Institute, Melbourne, and was presented at the World Federation of Occupational Therapists Congress, July 25–28, 2006, Sydney, New South Wales, Australia.

References


## Appendix.
### Edited Scoresheet From the Melbourne Assessment

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Scoresheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>Reach forward</td>
<td>1</td>
</tr>
<tr>
<td>Item 5</td>
<td>Drawing grasp</td>
<td>1</td>
</tr>
<tr>
<td>Item 6</td>
<td>Release of crayon</td>
<td>1</td>
</tr>
<tr>
<td>Item 7</td>
<td>Grasp of pellet</td>
<td>1</td>
</tr>
<tr>
<td>Item 9</td>
<td>Manipulation</td>
<td>1</td>
</tr>
<tr>
<td>Item 10</td>
<td>Pointing</td>
<td>1</td>
</tr>
<tr>
<td>Item 11</td>
<td>Reach to brush from forehead to back of neck</td>
<td>1</td>
</tr>
<tr>
<td>Item 13</td>
<td>Pronation/supination</td>
<td>1</td>
</tr>
<tr>
<td>Item 14</td>
<td>Hand-to-hand transfer</td>
<td>1</td>
</tr>
</tbody>
</table>

- 0: No performance
- 1: No ability
- 2: Moderate ability
- 3: Good ability
- 4: Excellent ability