Standardization of the Prone Extension Postural Test on Children Ages 4 Through 8

(vestibular function, sensory integration, pediatrics)

Janice L. Gregory-Flock  Elizabeth J. Yerxa

The prone extension postural test is a measurement of vestibular functioning that has been used by occupational therapists in assessing children suspected of having vestibular system deficits. The purpose of this study was to standardize the prone extension postural test because no standardized procedures or normative data were previously available for its administration.

Reliability and validity were estimated and normative data gathered on 242 normal children ranging in age from 4 through 8 years. Performance involving duration and score on a qualitative scale was recorded. Four and 5 year olds performed similarly and statistically, and significantly differently from 6, 7, and 8 year olds. When a small group of learning-disabled children was compared to a nondisabled group, the prone extension postural test differentiated between the two groups with the exception of the 4 year olds.

The prone extension postural test was intended to be used in conjunction with the Southern California Sensory Integration Tests for assessing brain mechanism deficits (1). These tests, together with clinical observations, constitute a major portion of the assessment tools used by occupational therapists for the identification of possible dysfunction within the sensory channels of the learning-disabled child. Because syndromes within the learning-disabled population are not generally exhibited discretely, it is essential that the occupational therapist use several measures of a particular dysfunction for adequate assessment. As a measurement tool, the prone extension postural test had been used with children aged 4 through 8 years without standardized assessment of the performance of this posture by normal children in a similar age range. This study provided a standardized method of administering and scoring the prone extension postural test. Reliability and validity were estimated, and normative data were obtained on children aged 4 through 8 years.

Literature Review
Ayres observed deficits in perceptual-motor skills as a characteristic of children with learning disabilities. She saw these deficits as symptoms of a greater dysfunction rather than as a problem by itself. Ayres posited that mastery of motor skills is a result of the brain's ability to process, integrate, and interpret sensory input coming simultaneously from several sensory modalities and to respond with an appropriate adaptive motor act (2). Thus the seat of the learning disability lies in the sensory integrative mechanisms of the brain. Sensory integrative theory builds on a foundation of developmental theory including the normal development of neuromechanisms that process and integrate sensory input. The theory hypothesizes that the neuromechanisms that process sensory input for motor skills are also nec-

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ecessary for the development of neuromechanisms that process sensory input for academic learning (2).

In the exploration of the sensory integrative mechanisms of the brain, Ayres, through a series of factor analytic studies, demonstrated relationships between various learning disability characteristics and specific sensory channels and sensory integrative mechanisms (3-7). More specifically, the factor analytic studies identified the "vestibular bilateral syndrome" that reflected the influence of the vestibular system upon postural skills and the bilateral integration of the body parts and functions. This syndrome is often manifested clinically as inadequate postural reactions, poor ocular pursuits, a hyporeactive nystagmus reflex, and resistance to crossing the midline in motor tasks. Inability to discriminate the right and left sides of the body and difficulty in rhythmical activities requiring temporal interrelationship of the two hands are also present (2-7).

The vestibular system plays an important role in developing postural responses and in maintaining posture. Posture is a motor response that reflects an individual's relationship to the earth's surface and gravitational force. This relationship involves position, equilibrium, and locomotion (8). Gravity is the source of sensory stimulation of the vestibular apparatus. The vestibular system influences the quality of motor responses through its ascending and descending neural tracts. This influence may be excitatory or inhibitory and is, in turn, influenced by the cerebellum and the reticular formation (9).

For example, the prone extension posture requires the vestibular system to signal that the head is down (pulled down initially by gravity and the tonic labyrinthine reflex in the infant). Through innervation along the vestibulo-spinal and medial longitudinal fasciculus tracts to the extensor muscles of the head, neck, and back, the head and eyes are lifted up for a horizontal visual orientation. This posture has been considered developmentally to be one of the first stability postures eliciting extensor control (10).

An inability to assume and maintain the prone extension posture was the primary indicator of the "vestibular bilateral syndrome" in Ayres' 1971 study (6). This posture was demonstrated by a child's ability to lie on his or her stomach and to lift the head, arms, legs, and feet off the floor smoothly and simultaneously and to hold that position for 20 to 30 seconds. In order to enhance the use of this test for the occupational therapist working with children who have sensory integrative dysfunction and to make it interpretable and generalizable, it needed to be standardized.

A standardized test is given each time in the same manner following a written procedure for test administration and scoring. It is also shown to be valid and reliable. In this study, interrater and test-retest methods were used as a means of establishing reliability. Harris employed a qualitative scale for the prone extension postural test establishing interrater reliability ($r = .89$) on that portion of the test (11).

Ayres' factor analytic studies provided support for congruent validity for the prone extension postural test (3-7). Congruent validity is established when correlational data are presented to show that performance on the specific instrument correlates with performance on some already existing and accepted measure of the characteristic under study (12). In those studies, the prone extension postural test consistently loaded with other measures of vestibular function and was shown to be a primary indicator of a syndrome of vestibular dysfunction (3-7). Ottenbacher added to congruent validity, showing that the prone extension postural test was a good predictor of postrotary nystagmus score (an accepted measure of vestibular function) (13).

In this study, validity was assessed through construct validity, which is the ability of the instrument to distinguish between groups known to behave differently on the variable under study.
Figure 2
Quality rating scale

Six categories
Assumes
0 does not assume
1 segmentally
2 smoothly and quickly, all body parts rise simultaneously

Head
0 face remains on mat
1 face raised less than 45° and/or position of head varies
2 face vertical (>45°) and held steady

Upper trunk
0 shoulders remain on mat
1 back minimally arched and/or elbows forward of shoulders
2 definite arch and elbows even with or back of shoulders

Thighs
0 thighs remain on mat
1 barely off, paper can be slid under knees, but not much above
2 clearly off the mat, from midthigh distally

Knees
0 knees remain on mat
1 definitely flexed (50° or more)
2 slightly bent (45° or less)

Maintains
0 minimal effort due to knees remaining on mat
1 considerable effort
2 moderate exertion expended

(12). A criterion is selected and used to identify two groups that behave differently on the variable.

The development of normative data is part of the standardization process (14). Normative data are based on actual performances, not predetermined levels, and provide the parameters of a “normal performance,” thus helping to define what is abnormal or dysfunctional by comparison. With normative data available for comparison, the prone extension postural test, as a standardized test developed to assess vestibular function, becomes a more valuable clinical tool for the occupational therapist.

Method

Subjects. Normal subjects were 242 children who attended public and private classrooms throughout the Los Angeles metropolitan areas and who returned parental consent forms. They represented lower, middle, and upper socioeconomic classes, with Caucasians and Hispanics predominating. Subjects ranged in age from 4 through 8 years and were grouped as follows: 43 four year olds (23 males, 20 females), 51 five year olds (29 males, 22 females), 49 seven year olds (27 males, 22 females), and 51 eight year olds (18 males, 33 females). These children were assumed to be normal based on their attendance in classrooms for normal children and by the lack of any documented orthopedic or academic handicaps known to their teachers.

Ten dysfunctional children (7 males, 3 females), ranging in age from 4 through 8 years and who were evaluated as learning disabled with vestibular dysfunction (measured by a postrotary nystagmus score of -1.0 standard deviations or below), were tested as the comparison group. These children had attended Dr. A. Jean Ayres’ Clinic from 3 to 18 months for sensory integrative therapy at the time of testing.

Procedure. This study was conducted in conjunction with a study of the supine flexion posture. Researchers were occupational therapy students who had not had previous pediatric experience, but who conducted a pilot study on the administration and scoring criteria for both postures under the guidance of an experienced occupational therapist. Normal children were tested on both postures and, for practical reasons, were tested in groups of five (each child was tested individually while the others looked on). The five children were tested in a random order with the prone extension postural test sometimes being given before and sometimes after the supine flexion postural test. In all cases, the children were given a 5-minute rest period between the testing for either posture. Dysfunctional children were tested individually on the prone extension postural test only, which was administered by the senior author who knew of their postrotary nystagmus scores. During the interrater reliability testing (n = 10), the senior author gave the instructions and scored performance while the other rater sat at one side, scoring only. For test-retest reliability (n = 14), two groups of children from two different schools were tested by using the same procedure twice, 1 week apart.

The procedure for administering the prone extension pos-
atural test was taken from Ayres (2). The child was tested lying on a carpet square and fully clothed. The examiner first asked the child to assume the prone extension posture in three steps as a practice trial. The trial required the child to lift first only the upper body, then with assistance, to lift only the lower body, and finally, with assistance, to lift both the upper and lower body together. During the practice trial the examiner instructed the child as follows: “Lie down on your tummy. Now lift your head and arms.” (The examiner assisted and/or corrected the position so that the head was vertical to the floor, and the arms were off the floor with flexed elbows at/or behind the shoulders and pronated palms.) “OK, rest. I want you to keep your legs straight and lift them like this.” (The examiner lifted the child’s extended legs, supporting them with one hand under the knees.) “Now lift your head and arms.” Throughout this practice trial, the examiner supported the child’s legs in order

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Duration</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fours* with fives†</td>
<td>$z = 1.54$</td>
<td>$z = -0.91$</td>
</tr>
<tr>
<td>Fours with sixes‡</td>
<td>$z = -5.77$</td>
<td>$z = 3.65$</td>
</tr>
<tr>
<td>Fours with sevens§</td>
<td>$z = -6.85$</td>
<td>$z = -4.91$</td>
</tr>
<tr>
<td>Fours with eights¶</td>
<td>$z = -7.24$</td>
<td>$z = -5.21$</td>
</tr>
<tr>
<td>Fives with sixes</td>
<td>$z = -4.48$</td>
<td>$z = 3.83$</td>
</tr>
<tr>
<td>Fives with sevens</td>
<td>$z = -6.00$</td>
<td>$z = -5.71$</td>
</tr>
<tr>
<td>Fives with eights</td>
<td>$z = -6.76$</td>
<td>$z = -6.02$</td>
</tr>
<tr>
<td>Sixes with sevens</td>
<td>$z = -2.33$</td>
<td>$z = -2.23$</td>
</tr>
<tr>
<td>Sixes with eights</td>
<td>$z = -3.79$</td>
<td>$z = -2.86$</td>
</tr>
<tr>
<td>Sevens with eights</td>
<td>$z = -2.01$</td>
<td>$z = -0.86$</td>
</tr>
</tbody>
</table>

* $N = 43$, † $N = 51$, ‡ $N = 48$, § $N = 49$, ¶ $N = 51$, †† Nonsignificant results

Table 2
Descriptive Statistics and Quartile Ranges (in seconds) for Duration Score for All Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>(% M F)</th>
<th>Quality</th>
<th>Duration</th>
<th>1st Quartile</th>
<th>2nd Quartile</th>
<th>3rd Quartile</th>
<th>4th Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 years</td>
<td>43</td>
<td>Median 8.5</td>
<td>Median 17.2</td>
<td>0–1</td>
<td>3–17</td>
<td>18–42</td>
<td>42–82</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median 8.0</td>
<td>Mode 11.0</td>
<td>0–9</td>
<td>10–30</td>
<td>31–60</td>
<td>61–130</td>
<td></td>
</tr>
<tr>
<td>5 years</td>
<td>51</td>
<td>Median 10.9</td>
<td>Median 62.5</td>
<td>0–48</td>
<td>53–62</td>
<td>63–77</td>
<td>101–241</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median 12.0</td>
<td>Mode 60.0</td>
<td>0–66</td>
<td>67–119</td>
<td>120–138</td>
<td>140–600</td>
<td></td>
</tr>
<tr>
<td>Learning</td>
<td>10</td>
<td>Median 7.5</td>
<td>Median 6.0</td>
<td>0</td>
<td>0–6</td>
<td>7–9</td>
<td>40–47</td>
<td></td>
</tr>
<tr>
<td>Disabled</td>
<td>30</td>
<td>Median 9.0</td>
<td>Mode 0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
to prevent fatigue. As soon as the child assumed the prone extension position shown in Figure 1, he or she was told to rest. It was explained that that position (head, arms, legs up) was the position required for the test. The practice trial described was repeated or a demonstration was given by the examiner if the child did not understand. Once the child understood, the child was told that he or she would be timed in that position.

The testing proceeded as follows: "You can help me count by watching the clock. I'll hold it here where you can see it. So, when I say 'go,' lift your head, arms, knees, and feet off the floor all at the same time and stay that way as long as you can. OK, go." The stopwatch was started when the child lifted both upper and lower extremities from the floor. The examiner slid a paper back and forth under the child's knees to be sure they were lifted off the floor during testing. The examiner asked the child to count out loud if he or she was holding his or her breath. When the child lowered knees, feet, and/or arms, with hands to the floor, the timing was stopped. This duration score reflected the total length of time in whole seconds that the child was able to maintain the posture. Each child was tested only once to avoid fatigue.

The quality rating scale developed by Harris was used in this study (11). Specific criteria for the scoring of zero were added by the senior author, as shown in Figure 2. The quality of performance was judged during the first 15 seconds of maintaining the posture with the best score being used. Performance in regard to duration and score for each of the six quality score categories and total was recorded. A quality rating score was given even if the duration score was zero.

**Results**

Statistical tests (Spearman's Rank Difference) showed the intrarater reliability coefficient on duration and quality scores to be $r = 1.00$ (15). The test-retest reliability coefficient on the duration score was $r = .79$, and on the quality score was $r = .77$. Reliability coefficients for quality were based on the total quality score. These coefficients indicated sufficient reliability to proceed with the standardization of the administration and scoring of the prone extension postural test.

Differences were found in performances between age groups (Mann-Whitney U Test) as shown in Table 1 (16). Four and 5 year olds were not significantly ($p < .05$) different from each other in duration or quality, but were significantly ($p < .001$) different from all other age groups. Six year olds performed significantly ($p < .02$) differently in both duration and quality from all age groups. Sevens and 8s performed similarly in both duration (mode = 120 seconds for both ages) and quality (median: 11.6 and 11.8, mode = 12 for both ages). Table 2 reflects
Table 3
Mann-Whitney U Test Comparisons in Performance among Learning-Disabled Children and 4 Year Olds, 5 Year Olds, and the Total Group of Normals

<table>
<thead>
<tr>
<th>Groups</th>
<th>Duration</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Rank</td>
<td>z</td>
</tr>
<tr>
<td>Normals* with learning disabled</td>
<td>129.97</td>
<td>$z = -3.72$</td>
</tr>
<tr>
<td>Four year olds§ with learning disabled</td>
<td>28.31</td>
<td>$z = -1.29$</td>
</tr>
<tr>
<td>Five year olds§ with learning disabled</td>
<td>33.31</td>
<td>$z = -2.30$</td>
</tr>
</tbody>
</table>

* N = 242.
† N = 10.
‡ N = 43.
§ N = 51.

the descriptive statistics and quartile ranges for duration scores for all groups. Figure 3 exhibits the frequency distributions of the total quality scores.

A statistical difference in duration ($p \leq .01$) and quality ($p \leq .04$) of performance was found between males ($n = 125$) and females ($n = 117$) (Kruskal-Wallis one-way analysis of variance) (15). When this was analyzed (Mann-Whitney U Test) by age group, the 4 year olds exhibited a significant ($p \leq .04$) difference in duration and a tendency for difference ($p \leq .07$) in quality. All other age groups showed no significant differences between sexes, but the mean rank scores generally reflected slightly higher performances by females.

A statistical difference ($p \leq .0002$) in performance in both duration and quality scores was seen when the normal ($n = 242$) and dysfunctional ($n = 10$) children were compared (Mann-Whitney U Test) (16). When each age group of normal children was compared to the learning-disabled group as a whole, the normal children had statistically significantly higher scores in both duration and quality except for the 4 year olds. The test's ability to discriminate between the two groups (normals and learning disabled), illustrated by these statistically significant differences in performance (with the exception of 4 year olds), provides evidence of construct validity for the prone extension postural test.

The frequency distributions of performance scores of the children with dysfunction were most similar to those of the 4 and 5 year olds. For this reason, a comparison of their performances was done (Mann-Whitney U Test) (16). The normal 5 year olds remained statistically significantly different from the learning-disabled group, whereas the 4 year olds were not statistically different in duration ($p = .19$), but there was a trend for them to do better on the quality scores ($p = .08$) (Table 3).

Discussion
The statistical differences between age groups and between normal and learning-disabled children should be noted. Four and 5 year olds performed similarly in both duration and quality and were distinctively different from the 6, 7, and 8 year olds. This finding is consistent with the Harris study that compared duration and quality of performance on the prone extension posture among 4, 6, and 8 year olds and found a statistically significant difference in performance between 4 and 6 ($p \leq .05$) and 4 and 8 ($p \leq .05$) (11). This research extends the Harris study by adding the 5 and 7-year-old age groups. Harris employed a smaller sample size ($n = 84$) from a more homogeneous population and limited the duration score to 30 seconds. She found no statistical difference between 6 and 8 year olds. This may have been due to the homogeneity of the sample and to the cut-off point on the duration time. The pattern of the data from this research suggested that the ability to assume this posture develops around the age of 4 and is well established by age 6 with some improvement in quality and duration through age 8. A group of 3 year olds and 9 year olds should be tested to verify this pattern.

Unlike the Harris study, a difference in performance was found between males and females (Kruskal-Wallis one-way analysis of variance) (15). Sample size may have been a factor (Gregory-Flock, $n = 242$; Harris, $n = 84$). When looked at within age groups, this difference was seen in the 4-year-old group only with the females.
Table 4
Percentage of Children Receiving a 0, 1, or a 2 on the Four Quality Categories: Performance Expectations by Group

<table>
<thead>
<tr>
<th>Quality Category</th>
<th>Score</th>
<th>Dysfunctional*</th>
<th>4 Year Olds†</th>
<th>5 Year Olds‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assume</td>
<td>0</td>
<td>40</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>20</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Thigh</td>
<td>0</td>
<td>40</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>20</td>
<td>20</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>40</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Knee</td>
<td>0</td>
<td>40</td>
<td>15</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>20</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>40</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Maintain</td>
<td>0</td>
<td>40</td>
<td>15</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>50</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

* N = 10.
† N = 43.
‡ N = 51.

Table 5
Duration in Seconds by Percentiles for Each Group: Performance Expectations by Group

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>Dysfunctional*</th>
<th>Fours†</th>
<th>Fives‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>0</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td>75</td>
<td>9</td>
<td>42</td>
<td>60</td>
</tr>
<tr>
<td>90</td>
<td>42</td>
<td>61</td>
<td>74</td>
</tr>
<tr>
<td>95</td>
<td>47</td>
<td>68</td>
<td>95</td>
</tr>
</tbody>
</table>

* N = 10.
† N = 43.
‡ N = 51.

performing higher in duration. A possible explanation is that the 4 year olds had not yet started public school and would not have been recognized as learning disabled. Learning disabilities are more frequent among males than females. A group of unrecognized learning-disabled children could influence the statistical differences. Further research is needed to clarify these differences.

When the learning-disabled children (n = 10) were compared as a group to the normal children (n = 242), there was a highly significant difference. However, when the learning-disabled children were compared as a group to the 4 year olds (n = 43) and the 5 year olds (n = 51), the differences in performances were not significant (p < .05) for the 4 year olds but were significant (p < .05) for the 5 year olds. These results suggest caution in assessing vestibular function in 4 year olds with the prone extension postural test. The quality of performance may be a more important factor in assessing the 4 years olds since that portion of the test did tend to discriminate learning-disabled children from nondisabled 4 year olds.

Because normal 4 and 5 year olds performed similarly and there was no significant difference between the performance of 4 year olds and the learning-disabled group, it is difficult to differentiate normal variability from dysfunctional variability in these age groups. The occupational therapist may use Tables 4 and 5, which provide performance expectations (numbers have been rounded for the sake of categories) in regard to age and in comparison to the learning-disabled group's performance. These figures were derived from the frequency distributions of performance within age groups. For example, a 4 year old who scores a 1 on the "assume" category of the quality rating scale would have done as well as 30 percent of his or her age group (see Table 4), whereas 20 percent did worse and 50 percent did better in that particular category. Similarly, if that 4 year old received a duration score of 5 seconds, he or she would fall into the second 25th percentile of his or her age group (see Table 5). These performance expectations may serve as a guide in assessing vestibular function in 4 and 5 year olds in that any child who falls into the lower 10 to 20 percent of the lower 25th percentile of his or her age group might be considered suspect of vestibular dysfunction if other assessment tools also point in that direction.

These results now enable the occupational therapist to identify more clearly the older child who has vestibular dysfunction. The
frequency distributions of this study showed that 75 percent of the 6, 7, and 8 year olds held the prone extension posture for at least 53 seconds, and 90 percent of all three age groups had an overall quality score of at least 10. As such, the performance expectations of this age range are, in general, a duration score of 60 seconds or better and a quality score of 10 or better.

Limitations
The samples selected in this research were samples of convenience. Children were assumed to be normal based on their attendance in classrooms for normal children and by having no known orthopedic or academic handicap. The comparison group of learning-disabled children (n = 10) was small and varied in age (4 through 8 years old) in contrast to the group of normals (total n = 242; 4 year olds, n = 43; 5 year olds, n = 51).

Summary
This study provided a standardized method of administering and scoring the prone extension posture test. The reliability coefficients and the test’s ability to discriminate between nondisabled (5 years and older) and learning-disabled children were adequate to support its use as an assessment and research tool. The performance by children, ages 4 through 8, followed a developmental trend that further supported the developmental foundation upon which sensory integrative theory is based.

This paper provides new findings and guidelines for the occupational therapist in assessing vestibular function with the prone extension posture test. Four and 5 year olds may hold the posture for only a few seconds and show a quality score of 9 or less and still fall within the average range of that age group. This performance might have been previously thought of as dysfunctional without such documentation of age differences. Because it is difficult to interpret the variability in the performance of 4 and 5 year olds, Tables 4 and 5 provide information to help differentiate a normal from a dysfunctional response. The performance expectation for children 6 years and up was higher than previously thought, with the expected duration score being 60 seconds or more and a quality score of 10 or better. In the past, children who were 6 years and older and who were able to maintain the prone extension posture for only 20 seconds (previously set parameter, 2) might have been considered normal when, in fact, dysfunction may have been present. As a standardized research and assessment tool, the occupational therapist may use the prone extension posture test with caution with 4 year olds and with confidence in children 5 years and older.

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REFERENCES