Vestibular-Proprioceptive Functions in 4 Year Olds: Normative and Regression Analyses

Margaret A. Short, P. J. Watson, Kenneth Ottenbacher, Charlotte Rogers

Normalive data were obtained for 156 pre-school children’s performances on measures of muscle tone, muscle co-contraction, standing balance, prone extension posture, flexion supine posture, asymmetrical tonic neck reflex, and postrotary nystagmus. Regression analysis indicated that these combined variables accounted for only 13.5 percent of the variance of postrotary nystagmus of 145 four year olds. However, if the data are examined only for children exhibiting nystagmus that is lower than 1 standard deviation below the mean, then these variables account for 50 percent of the variance of nystagmus. Prone extension posture, standing balance-eyes closed, and muscle tone account for 37 percent of the variance within this low-nystagmus population. These results are considered in light of the authors’ previous studies demonstrating that, in learning-disabled children, vestibular-proprioceptive measures can be used clinically to predict which children will respond to sensory integration therapy with changes in postrotary nystagmus. These changes, according to sensory integration theory, reflect positive responses to therapy.

Margaret A. Short, Ph.D., OTR, was mental health consultant and occupational therapist for the City of Chattanooga Human Services-Head Start Program when this study was conducted. She is currently Assistant Professor of Occupational Therapy, Department of Occupational Therapy, Sargent College of Allied Health Professions, University Road, Boston University, Boston, Massachusetts 02215.

P. J. Watson, Ph.D., is Assistant Professor of Psychology, University of Tennessee at Chattanooga.

Kenneth Ottenbacher, Ph.D., OTR, is Assistant Professor, Occupational Therapy Program, University of Wisconsin-Madison, Madison, Wisconsin.

Charlotte Rogers was an occupational therapist with the City of Chattanooga Human Services-Head Start Program when this study was conducted. She is currently Director of Occupational Therapy, Vanderbilt University Hospital, Nashville, Tennessee.

The early identification of handicapping conditions has received considerable recent focus; however, normative data and standardized evaluations for the assessment of children aged 4 years and younger are still lacking. This lack is particularly evident in the assessment of learning disabilities, which encompass conditions such as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia (1, 2). The deficits associated with these conditions vary from emotional disturbances and academic difficulties to abnormal neurobehavioral symptoms. This latter category, sometimes referred to as “soft” neurological signs, includes motor incoordination or clumsiness, abnormal muscle tone, impaired balance, and other measures of vestibular and proprioceptive functions (3). These soft signs serve as aids in the identification of subcategories of learning disabilities (4).

Because the term learning disabilities represents a broad category of diverse disorders, its usefulness as a diagnostic criterion has been criticized (5). Research has been aimed at identifying subcategories, or syndromes of learning disabilities (6). The Southern California Postrotary Nystagmus Test (SCPNT) (7) is one index that has proved useful for elucidating these subcategories. The SCPNT is a standardized test...
that measures the duration of ocular movement (nystagmus) following rotation. Using the SCPNT, Ottenbacher (8) demonstrated that in school-age children diagnosed as exhibiting learning disabilities, minimal brain dysfunction, or perceptual motor disorders, the duration of postrotary nystagmus (PRN) is directly related to other “soft” neurological signs or measures of vestibular and proprioceptive function. Using these “soft” measures of balance, muscle tone, and prone extension posture, Ottenbacher, Short, and Watson (9) were able to predict which learning-disabled children with low postrotary nystagmus would respond with duration increases following sensory integrative therapy (SIT).

The measure of PRN has thus proven useful for the delineation of specific subgroups of school-age learning-disabled children who will respond to therapy, and 2, in combination with four other measures, for prediction of the low-nystagmus learning-disabled children who will respond with duration increases following SIT. Change in the duration of PRN is an important goal of SIT (10), which has been found effective in ameliorating the academic deficits of learning-disabled children displaying hyporeactive PRN (11); however, depressed nystagmus can be caused, not only by vestibular processing deficits (10), but also by visual fixation, by reductions in arousal (12), or by light in the visual field (13). Not all learning-disabled children with depressed PRN exhibit increases in nystagmus following SIT (9), indicating, possibly, that for these children other forms of intervention may be warranted. It is important that therapists be able to predict which clients will be receptive to specific interventions so that the most appropriate therapy be introduced as early as possible. Ottenbacher, Short, and Watson (9) reported that, by combining global measures of vestibular-proprioceptive and postural responding with the SCPNT, therapists are able to enhance their diagnostic procedures with learning-disabled children (8, 9).

PRN has been investigated primarily in samples of school-age children (7, 14), and published norms do not exist for large samples of preschool children. Recently, in an investigation of the test-retest reliability of the duration of SCPNT scores in 3 and 4 year olds, norms were reported for 28 and 42 subjects, respectively (15). The authors of that study concluded that “Since the study was supportive of acceptable test-retest reliability for four-year-olds, additional reliability, validity and normative studies with this age group should be undertaken.” (p 175)

Although it has been suggested (16) that “soft” neurological signs are more evident at earlier ages and become progressively more difficult to obtain, these signs have not been extensively examined in pre-school children. It might be expected that clinical assessment of vestibular and proprioceptive functions may be easier to obtain with a younger population. In addition, it is not known what relationships exist between these clinical assessment variables when they are obtained from a pre-school population. Using measures of postural control, reflex integration, and bilateral motor integration, DeGangi, Berk, and Larsen (17) reported that these vestibular-based measures showed strong discriminative ability for separating normal and delayed preschool children. The primary purpose of the present study was to examine 4-year-old Head Start children’s performance abilities on assessments of vestibular and proprioceptive functions—that is, muscle tone, various postures, balance, and PRN. A second objective was to obtain normative data for these measures and to explore the nature of the relationship between these variables and PRN within a subject sample of 4 year olds.

Method

Subjects. As part of the regularly scheduled screening procedures for all 4 year-old children participating in the Chattanooga area Head Start Programs, 177 four-year-old children were evaluated by one of two occupational therapists experienced in pediatric therapy. Eliminated from the sample were any children who were extremely passive or uncooperative, who refused the testing or could not remain seated on the nystagmus board, who exhibited strabismus, or who had received previous diagnoses of mental retardation or neurological disorders. As a result, the total number of subjects consisted of 136 children, 72 males and 84 females, of Black and Caucasian races, from rural and urban environments, and ranging in age from 47 to 60 months.

Procedure. In a quiet section of the children’s classroom or in a separate room, clinical assessments of muscle tone: co-contraction; prone-extension posture: supine flexion posture; one foot, standing balance-eyes open; one foot, standing balance-eyes closed; asymmetrical tonic neck reflex; and postrotary nystagmus were conducted. Standing balance was assessed according to the instructions in the Southern California Sensory Integration Tests (SCSIT) (18); nystagmus was assessed according to the standardized instructions of the SCPNT (7):
and the other five assessments were modified from those reported by Ottenbacher (8). Modifications of the five assessments were conducted in order to increase the objectivity of assessment and scoring and to enhance communication with younger subjects. The instructions and modifications are included for comparison with Ottenbacher's methods. (It should be noted that, after this study was conducted, Dunn published A Guide to Testing Clinical Observations in Kindergartners (19). This guide incorporates clear instructions, illustrations of positions, criteria for scoring, and normative data for clinical assessments including the five measures modified for this study.)

Muscle Tone (MT). Using a goniometer, the degree of flexion (measured as a negative number) or hyperextension (measured as a positive number) of the elbows is gauged. While seated in a child's chair, the child is assessed with both arms relaxed and at his or her sides. Each arm is passively extended by the therapist and scores are obtained for the right side (MT-R), and for the left side (MT-L), and a combined score (MT) is determined.

Muscle Co-Contraction (CO). The therapist and child sit facing one another. The child is instructed: "Hold onto my thumbs and keep your elbows straight." (The child's thumbs and elbows are touched and pointed out to him or her.) A practice trial is given, and, if the child flexes and extends the elbows, he or she is shown how to hold the elbows straight without locking them: "Don't bend your elbows. Now don't let me push you or pull you. Keep your arms straight." Scoring is a 1: elbows straight without locking them; 2: elbows show some flexion (5-30°) when alternatively pushed and pulled; 3: elbows flex notice-

Table 1
Norms for Clinical Assessments of 4 Year Olds

<table>
<thead>
<tr>
<th>Assessments</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>No. Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO* (score 1,2,3)</td>
<td>1.34</td>
<td>.57</td>
<td>1 to 3</td>
<td>156</td>
</tr>
<tr>
<td>MT-L (-°; +°)</td>
<td>2.97</td>
<td>5.00</td>
<td>-10 to +20</td>
<td>155</td>
</tr>
<tr>
<td>MT-R (-°; +°)</td>
<td>3.75</td>
<td>4.67</td>
<td>-8 to +22</td>
<td>155</td>
</tr>
<tr>
<td>MT (-°; +°)</td>
<td>6.7</td>
<td>9.02</td>
<td>-17 to +37</td>
<td>155</td>
</tr>
<tr>
<td>PEP (0 - 20)</td>
<td>5.5</td>
<td>7.36</td>
<td>0 to 20</td>
<td>152</td>
</tr>
<tr>
<td>SFP (0 - 20)</td>
<td>14.3</td>
<td>6.07</td>
<td>0 to 20</td>
<td>155</td>
</tr>
<tr>
<td>ATNR-L (1,2,3)</td>
<td>1.76</td>
<td>.73</td>
<td>1 to 3</td>
<td>153</td>
</tr>
<tr>
<td>ATNR-R (1,2,3)</td>
<td>1.9</td>
<td>.76</td>
<td>1 to 3</td>
<td>150</td>
</tr>
<tr>
<td>ATNR (2 - 6)</td>
<td>3.7</td>
<td>2.5</td>
<td>2 to 6</td>
<td>146</td>
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<tr>
<td>SBO-L (0 - 30)</td>
<td>6.69</td>
<td>5.84</td>
<td>0 to 24</td>
<td>156</td>
</tr>
<tr>
<td>SBO-R (0 - 30)</td>
<td>6.87</td>
<td>5.92</td>
<td>0 to 30</td>
<td>156</td>
</tr>
<tr>
<td>SBO (0 - 60)</td>
<td>13.56</td>
<td>10.10</td>
<td>0 to 40</td>
<td>156</td>
</tr>
<tr>
<td>SBC-L (0 - 30)</td>
<td>2.10</td>
<td>1.97</td>
<td>0 to 14</td>
<td>156</td>
</tr>
<tr>
<td>SBC-R (0 - 30)</td>
<td>2.01</td>
<td>2.21</td>
<td>0 to 14</td>
<td>156</td>
</tr>
<tr>
<td>SBC (0 - 60)</td>
<td>4.1</td>
<td>3.85</td>
<td>0 to 28</td>
<td>156</td>
</tr>
</tbody>
</table>

*See text for explanation of abbreviations for clinical assessments
<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>No. of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combined Males and Females</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRN-Left</td>
<td>9.08</td>
<td>6.12</td>
<td>0-34</td>
<td>156</td>
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<tr>
<td>PRN-Right</td>
<td>9.28</td>
<td>6.75</td>
<td>0-40</td>
<td>156</td>
</tr>
<tr>
<td>PRN-Total</td>
<td>18.34</td>
<td>11.95</td>
<td>0-60</td>
<td>156</td>
</tr>
<tr>
<td><strong>Females</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRN-Left</td>
<td>9.24</td>
<td>5.42</td>
<td>0-27</td>
<td>81</td>
</tr>
<tr>
<td>PRN-Right</td>
<td>9.23</td>
<td>6.63</td>
<td>0-27</td>
<td>81</td>
</tr>
<tr>
<td>PRN-Total</td>
<td>18.46</td>
<td>11.15</td>
<td>0-54</td>
<td>81</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRN-Left</td>
<td>8.9</td>
<td>6.89</td>
<td>0-34</td>
<td>72</td>
</tr>
<tr>
<td>PRN-Right</td>
<td>9.3</td>
<td>6.94</td>
<td>0-40</td>
<td>72</td>
</tr>
<tr>
<td>PRN-Total</td>
<td>18.2</td>
<td>12.89</td>
<td>0-60</td>
<td>72</td>
</tr>
</tbody>
</table>

Ably (35° or more) upon alternate pushing and pulling. If a child locks elbows in extension, he or she is shown how to relax the elbows and is given a second trial. If he or she still locks the elbows, a 3 is scored.

**Prone Extension Posture (PEP).** The child is asked to lie down and fly like a bird. The child may be placed in position or it may be demonstrated. The position is hyperextended posture with legs and arms abducted, elbows flexed, and head held above the supporting surface. The child and therapist count to see how long the child can maintain the posture—up to 20 seconds. The score is the duration (in seconds) the posture is held without having the head, arms, or knees touch the surface.

**Asymmetrical Tonic Neck Reflex (ATNR).** The child is asked to get on his or her hands and knees, “like a dog.” (The child may be placed in position, or it may be demonstrated.) The position is quadruped. The therapist turns the child’s head to the right and to the left, and observes the amount of elbow flexion as the head is turned. The head is not held in passive rotation at the end of the range, but the response is scored as the head is passively rotated toward the end of the range. A score is obtained for elbow flexion to the right (ATNR-R) and to the left (ATNR-L) as well as a combined score ATNR. A score of 1 is given if there is no flexion; 2, if there is slight flexion to 30°; 3, if there is pronounced flexion over 35°. Combined scores range from 2 to 6.

**Supine Flexion Posture (SFP).** The child is asked to roll up in a ball. (The child may be placed in position, or it may be demonstrated.) The position is flexion posture with arms crossed on chest, ankles crossed, and neck, hips, and knees flexed.
flexed. The child and therapist count to see how long the child can maintain the posture—up to 20 seconds. The score is the duration, in seconds, the posture is held without having the legs, neck, or arms touch the surface or without breaking the symmetrical flexion posture, for example, if the child starts extending a leg, the neck, or the arms.

**Standing Balance—Eyes Open (SBO).** The child is asked or shown how to stand with the arms folded across the chest. As in SCSIT procedures, touching the child’s left leg, the therapist asks the child to lift the foot and to keep still, not to hop or move around. The score is the duration in seconds the child holds the foot up without unfolding the arms, moving the standing foot, or touching the other foot to the ground. Score is only counted if the child maintains an erect posture and does not rest the lifted foot against the other leg. If a child does not understand, the knee is bent and placed in position as a demonstration. Instructions are repeated for lifting the right foot. Scores are obtained for the right leg (SBO-R), the left leg (SBO-L), and combined (SBO).

**Standing Balance—Eyes Closed (SBC).** This is conducted the same as SBO except that the child keeps the eyes closed. The duration in seconds for maintaining the posture with the right leg (SBC-R), the left leg (SBC-L), and both legs (SBC) is recorded.

**Postrotary Nystagmus (PRN).** This is administered according to standardized instructions in the SCPNT. Scores are obtained for the duration of PRN to the right (PRN-R), after rotation to the left (PRN-L), and combined (PRN).

The clinical assessments were administered in the order they are presented above and took between 10 and 20 minutes per child. Scores were recorded on a separate score sheet developed for this study. Although interobserver reliability scores were not obtained throughout data collection, the therapists worked closely developing high levels of agreement on all items before assessing the sample for this study. Both therapists were experienced with the clinical observations from the SCSIT (18), from which Ottenbacher’s(8) assessments were obtained. One therapist had learned the criteria from Ottenbacher and taught those criteria to the second therapist. The score sheet for testing included space for comments; if a child responded in an idiosyncratic manner, this response was recorded.

**Results.** Because of occasional missing data points, the sample sizes vary for the normative data. This is noted in Table 1 where sample sizes vary from 152 to 156. Because of the nature of the computer program (20), the multiple regression analysis as well was conducted only for subjects for whom all data points were complete; therefore, the sample size for the regression was 145.

The normative data including means, standard deviations, and ranges for all of the clinical assessments except PRN are included in Table 1. These data are reported for combined scores as well as, where possible, for bilateral responses. The data for SCPNT are reported in Table 2 and also include a breakdown of scores based on sex and right and left responses.

Because Ayres (7) and Kimball (14) found discrepant results in the sex differences in the variances of PRN for 5 to 9 year olds, a test for difference between variances (21) was conducted for this study. The results indicated no significant differences between the PRN variances of the males and females ($F = 1.34, df = 71/183, p > .05$). In addition, a one-way Analysis of Variance, with sex as the independent variable and nystagmus as the dependent variable, indicated no significant differences between the males and females in their PRN responses ($F = .01, df = 1/155, p > .9$).

Using PRN as the dependent variable and MT, ATNR, CO, PEP, FSP, SBO, SBC, and sex as independent variables, a step-wise multiple regression (14) was used to determine the relationship of the independent variables in predicting PRN. The single best predictor was CO, but this only accounted for 7 percent of the variance of PRN. The remaining variables, in order of amount of contribution to the prediction of PRN are: PEP, FSP, ATNR, SBO, sex, and MT. SBC contributed so little that it was not included in the regression. Together

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Relation Between Postrotary Nystagmus and Clinical Assessments in 4-Year-Old Children*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regression R-Square</td>
</tr>
<tr>
<td>CO</td>
<td>.07</td>
</tr>
<tr>
<td>PEP</td>
<td>.04</td>
</tr>
<tr>
<td>FSP</td>
<td>.02</td>
</tr>
<tr>
<td>ATNR</td>
<td>.01</td>
</tr>
<tr>
<td>SBO</td>
<td>.001</td>
</tr>
<tr>
<td>SEX</td>
<td>.0005</td>
</tr>
<tr>
<td>MT</td>
<td>.0002</td>
</tr>
<tr>
<td>Cumulative total</td>
<td>1.35</td>
</tr>
</tbody>
</table>

*N = 145
Table 4
Relation Between Postrotary Nystagmus and Clinical Assessments in 4-Year-Old Children with Low Nystagmus*

<table>
<thead>
<tr>
<th>Regression Coefficient (Simple r)</th>
<th>Correlation Coefficient (Simple r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEP</td>
<td>.12</td>
</tr>
<tr>
<td>SBO</td>
<td>.12</td>
</tr>
<tr>
<td>MT</td>
<td>.13</td>
</tr>
<tr>
<td>SEX</td>
<td>.03</td>
</tr>
<tr>
<td>SFP</td>
<td>.02</td>
</tr>
<tr>
<td>SBC</td>
<td>.03</td>
</tr>
<tr>
<td>CO</td>
<td>.04</td>
</tr>
<tr>
<td>ATNR</td>
<td>.001</td>
</tr>
</tbody>
</table>

Cumulative regression $R^2$ = .498

*Less than one standard deviation below the mean, $N = 25$

the variables only accounted for 13.5 percent of the variance of PRN. The cumulative regression $R^2$-squares as well as simple $r$s, showing the correlation of nystagmus with each of these variables, are included in Table 3.

Because of the recent findings that clinical variables may be better predictors of PRN for children who exhibit depressed nystagmus (9), an additional regression was conducted using the same independent variables to predict PRN. This was conducted, however, only for subjects who scored lower than 1 standard deviation below the mean on the SCPNT. Twenty-eight subjects evidenced nystagmus of 6 seconds or less; however, because of missing data points, the regression analysis was performed on 25 children.

For these subjects, the independent variables, in order of contribution to the regression, are PEP, SBO, MT, sex, SFP, CO, and ATNR. PEP was the best predictor, accounting for 12 percent of the variance; PEP, SBO, and MT together accounted for 37 percent of the variance of PRN, and all of the variables accounted for 50 percent. The cumulative regression $R^2$s and simple $r$s are included in Table 4.

**Discussion**
A large quantity of data was generated in this study. The normative data for all of the clinical assessments may be useful for other therapists using such evaluations with other preschool populations. Some of the tasks, notably PEP and SBC, were difficult for the 4-year-old children. For example, the mean SBC score was 4.1 seconds compared with the mean of SBO, which was 13.56 seconds. The mean PEP score was 2.5 seconds compared with SFP, which was 14.3 seconds. Dunn's (19) assessments of 5-year-old children are similar. She reports that "It seems reasonable to expect five-year-olds to execute the supine flexion posture and hold it without resistance for a period of time." (p 21)

However, on the prone extension posture with legs straight, "many children exhibited so short a duration performance that it would be difficult to separate normal children who could not maintain the posture very long from children with difficulty." (p 24) This is in contrast with Harris' (22) report of mean scores of 18.15 seconds for 4-year-olds' performance on prone extension. One possible explanation for this difference is that the present study and Dunn's guide (in position #3) required the child to extend at the hips, keeping the knees straight, and maintaining the knees off the supporting surface. It is not clear whether Harris maintained this strict criterion. Many children in the present study could have assumed and maintained the PEP posture for much longer if the leg extension criterion had not been included. Dunn (19) confirms this.

Looking at four different extension postures, she reported that the three that required leg extension, with the legs off the floor, were very difficult for kindergarten children. Another possible explanation for the difference between the PEP scores in the present study and Harris' scores is the difference in duration of holding the posture. The present study stopped at 20 seconds, whereas Harris continued to 30 seconds. It is possible that a ceiling effect in this study caused the mean to be much lower than Harris's. This is a doubtful explanation, however, because only 19 children in the present study were able to maintain the posture for 20 seconds, compared with at least 3 times that number who could not even assume the posture.

The nystagmus duration scores for the males and females combined in this study are similar to those combined scores for 4-year-olds examined by Deitz, Seigner, and Crowe (15). Their initial SCPNT duration mean was 19.57 seconds compared with their re-test score of 18.93 seconds, and compared with 18.34 seconds in this study. The data are more variable, however, when they are separated by sex. In the study by Deitz, et al., the mean total SCPNT duration for males (initial: 21.87 sec, re-test: 20.87 sec) and females (initial: 16.79 sec, retest: 16.58 sec) differs by 4-5 seconds. In the present study, the mean scores for the males (18.2 sec) and females (18.46) do not differ but are less than the scores for males and greater than the scores for females reported by Deitz, et al. It is not reported whether Deitz, et al., found signifi-
cant sex differences, but of the 5- to 9-year-olds investigated by Ayres (7), significant sex differences between the variances of the SCPNT duration scores necessitated the development of separate standardization data for each sex. Kimball (14) and the present study reported no such significant sex differences.

Another difference between all of these studies is variability. In Ayres' manual of normative data for SCPNT scores for 5 to 9 year olds, no subjects received a total score of zero; and the maximum longest duration was 24 seconds (7). In the present study, 7 males and 4 females exhibited nystagmus durations of zero; and the maximum PRN duration in one direction was 70 seconds. Obviously, this sample is more variable, with a combined (male-female, right-left) standard deviation of 11.9 seconds, compared with Ayres' 7 seconds, Kimball's 9.67 seconds, and 6.87 seconds reported by Deitz, et al. Kimball has discussed the implications of interpreting PRN data with higher variability; essentially, it causes an increased range of scores that are considered to be within normal limits and increases, especially the cut-off point for determining whether a score is deviantly high. Because her data were more variable than those reported by Ayres (7), Kimball has suggested that there may be regional differences in the norms for PRN and that this needs to be further examined (14). The present study presents similar problems because of high variability, which could, in part, be due to lack of interobserver reliability. It should be pointed out that both Ayres' (7) and Kimball's (14) data were obtained from middle class, non-Black populations. Deitz, et al., do not specify the racial or economic background of their sample, which comes from a metropolitan area in the state of Washington. The present study was conducted with a lower class, mixed race, Southern, combined urban and rural population. Whether the causes for such differences in variability between studies is due to sample characteristics such as geographic, racial, or economic background or other factors needs further exploration. In addition, the reasons for discrepancies in sex differences between studies will require further experimental analysis.

Ottenbacher (8) reported that the variables PEP, SBC, MT, and SBO share significant variance with SCPNT scores obtained in school-aged children diagnosed with learning disabilities, minimal brain dysfunction, or perceptual motor disabilities. The present study, using the same clinical assessments, was able to account for only 13.5 percent of the variance of SCPNT scores in normal Head Start 4-year-old children. This suggests that these variables may not be clinically useful for screening normal 4 year olds for possible manifestation of vestibular deficits. That these variables are useful, however, for subdividing populations of children already diagnosed as learning disabled has been demonstrated (9). Thus, the measures of balance, tone, and extension posture may show better predictive relationships in children with depressed nystagmus. In the present study, PEP, SBO, MT, sex, SFP, SBC, CO, and ATNR (in that order) accounted for 50 percent of the variance of SCPNT scores that were less than 1 standard deviation below the mean. Clyse (23) has demonstrated that a measure of dynamic balance may be an even better indicator of vestibular dysfunction than standing balance. She reported that the walk-on-floor-eyes-closed test of the Floor Ataxia Test Battery (24), a measure of dynamic balance, in combination with PEP, accounted for 50 percent of the variance of SCPNT scores in school-aged children with learning disabilities or perceptual motor dysfunction.

In the present study, in the sample of children with depressed nystagmus, the variable muscle tone shows an inverse correlation with SCPNT. This means that, as the score on tone increases, nystagmus decreases. With the method of assessing muscle tone for this particular study, hyperextension is a positive score so that these data are consistent with Ottenbacher's (8) report that low nystagmus is correlated with hypotonia. Whether the muscle tone assessment used in this study is an adequate and accurate reflection of tone is questionable. However, using this particular measure makes it possible to compare with Ottenbacher's previous studies (8, 9) and provides a quantitative measure. In her clinical assessment of tone, Dunn (19) also measures hyperextensibility of the elbow joint; however, in addition, she includes a measure of palpation. Dunn reports that "clinical impressions from palpation of muscles may be more helpful than measurement of the elbow joint in determining the integrity of muscle tone." (p 8) The problem with using palpation as a variable is that it is difficult to objectively and quantitatively.

Implications for Occupational Therapy. The study of learning disabilities in pre-school populations is particularly difficult. These children have not yet acquired many of the fine, perceptual-motor, academic abilities that are used to gauge learning disabilities in older children. Therefore, clinical observations of tone, reflex integra-
tion, posture, and postrotary nystagmus, which are useful for indicating vestibular-processing deficits in school-age learning-disabled children (9, 23) may also be useful for discriminating delayed pre-school children (17). Standardized assessments and norms for these sensorimotor abilities are limited (17), although the present study and other recent investigations have contributed information on the performance of pre-school children on postrotary nystagmus (15), prone extension posture (22), and many other clinical observations (19). The results of the present study suggest that, in contrast to their use with school-age learning-disabled children, clinical measures of tone, balance, and extension posture are not good predictors of depressed nystagmus in a large group of normal pre-school Head Start children. It is suggested, as has been with other learning-disabled children (8, 9, 23), that, if therapists use clinical measures to predict possible vestibular deficits, they include a constellation of measures along with SCPNT scores. This shows the need for normative measures of all clinical variables including SCPNT scores for 3, 4, and 5 year olds. The study by Deitz et al. (15) and the present study provide some norms; however, due to sex differences, and possible racial or regional differences (7, 14), it is advisable that more normative data be acquired in order to present a clear profile of the SCPNY scores of pre-school children (15). Therapists should also be cautious in generalizing the data from this study because of the lack of intertester reliability determination throughout the study and because Head Start children may not be representative of all pre-school children. These data can be used, in combination with other normative measures, as guides for performance skills.

The results from this and from Dunn’s guide (19) suggest that some clinical measures are not particularly useful for pre-school children. The skills of one-leg-standing—eyes closed, and prone extension posture with legs extended off the supporting surface, are very difficult for 4-year-old and kindergarten children (19) and therefore may not be useful assessment criteria. The regression analyses from this study suggest that continued research needs to be conducted into the relationship between clinical observations and vestibular functions in pre-school children.

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REFERENCES
10. Ayres AJ: Sensory Integration and Learning Disorders. Los Angeles: Western Psychological Services, 1972